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THE UNIVERSITY OF ALBERTA

LATE GLACIAL GEOLOGY OF THE FINLAY RIVER VALLEY, BRITISH COLUMBIA

BY

LOUISE E LESLIE

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE

DEPARTMENT OF GEOLOGY

EDMONTON, ALBERTA

SPRING, 1988

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ABSTRACT

The landforms and deposits of the Finlay River Valley indicate the occurrence of major glacial activity in the past. The glacial landforms indicated on the surficial map of the area include drumlins, grooves, eskers, and meltwater channels. The surficial deposits are divided into Holocene and Pleistocene deposits. Holocene deposits include organic, alluvial, and fluvial units. Pleistocene deposits include glaciofluvial, glaciolacustrine, and morainal units.

Morainal units form approximately 95% of the surficial deposits, represented by four diamicton types; 1, 1A, 1B, and 2. Type 1 Diamicton is interpreted to be a subglacial till based on the massive texture, ordered fabric, and lack of sorted sediments. Type 1A Diamicton is a lodgment till based on fissility and a well ordered fabric. The coarse-textured diamicton and preserved sand and gravel lenses at and near the base of the unit show Type 1B Diamicton to be a modified subglacial meltout till. Type 2 diamicton is interpreted to represent debris flow deposits on the bases of locally variable fabric orientations, the occurrence of diamicton interstratified with sand and gravel sediments, and the geometry of the diamicton beds.

Distribution of glacial landforms, such as drumlins and grooves, origin of morainal deposits, and lack of supraglacial deposits suggest that a) glacial debris was mostly subglacially transported and deposited, b) glacial ice flowed into the Finlay River Valley from the east and west, and c) more ice entered the valley from the west

compared to the east. Deglaciation of the valley was continuous. There are no moraines or glaciofluvial ice-contact deposits which suggest the occurrence of a glacial stand-still.

Fluvial deposits represented by floodplains and terraces form most of the Holocene deposits. Terraces, dating from 3440 +/- 60 to 5780 +/- 110 years BP, suggest that they are not related to the deglaciation of the valley. Hence, their formation was probably the result of climatic fluctuations.

Acknowledgements

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CHAPTER 1

A. INTRODUCTION

One of the main reasons for choosing the Finlay River Valley is that it is one of the many areas of the Canadian Cordillera where glacial ice centres and flow patterns are poorly documented. Prest (1969) shows that the major ice centre initiated from a Cordilleran ice cap is situated west of the Finlay River Valley. Mathews (1980) has mapped drumlins oriented parallel to the valley trend which indicate a down-valley ice-flow direction. These regional studies provide a very limited glacial history of the Finlay River Valley area. Although not all areas are suitable for a detailed study, the following factors allowed for such a study in the Finlay River Valley: a) glacial sediments are frequently exposed along the Finlay River; b) there are two airfields located in the map area that are presently in use; and c) the Finlay River can be navigated easily by boat throughout the summer months.

Objectives

Based on these factors the following objectives were chosen:

1. To map and describe the surficial deposits and landforms of the Finlay River Valley, British Columbia;
2. To give a detailed description and interpret the depositional environment of the surficial morainal deposits exposed in vertical section;

3. To interpret the processes responsible for the formation of the surficial deposits and landforms of the Finlay River Valley; and

4. To comment on the late glacial history based on the interpretations above.

STUDY AREA

Location and Physical Setting

The Finlay River Valley (Figure 1.1) is located in northcentral British Columbia (Ware Map Sheet 94F) and forms part of the Northern Rocky Mountain Trench. The Trench is bordered on the east by the Muskwa Ranges of the Rocky Mountains, and on the west by the Finlay Ranges of the Omineca Mountains (Holland 1972). The northern boundary of the map area occurs at the settlement of Fort Ware where the Finlay River enters the Northern Rocky Mountain Trench. The southern boundary occurs south of the confluence of the Akie and Finlay Rivers.

The relief on either side of the valley varies slightly. Individual mountains, such as the Kwadacha Mountain, Mount Paul, Grave Mountain, Mount Del, Mount Blanchard, Truncate Mountain, and Akie Mountain, make up the eastern edge of the map area. They are well vegetated, with gentle slopes and rounded tops reaching elevations between 1300 to 1700 m a.s.l. Mount Bennett is the highest feature in the map area reaching elevations above 1900 m a.s.l. and is located in the northwest part of the map area. South of Mount Bennett a continuous mountain range of the Finlay Ranges with slightly steeper slopes, forms the western boundary of the map area, reaching elevations between 1500

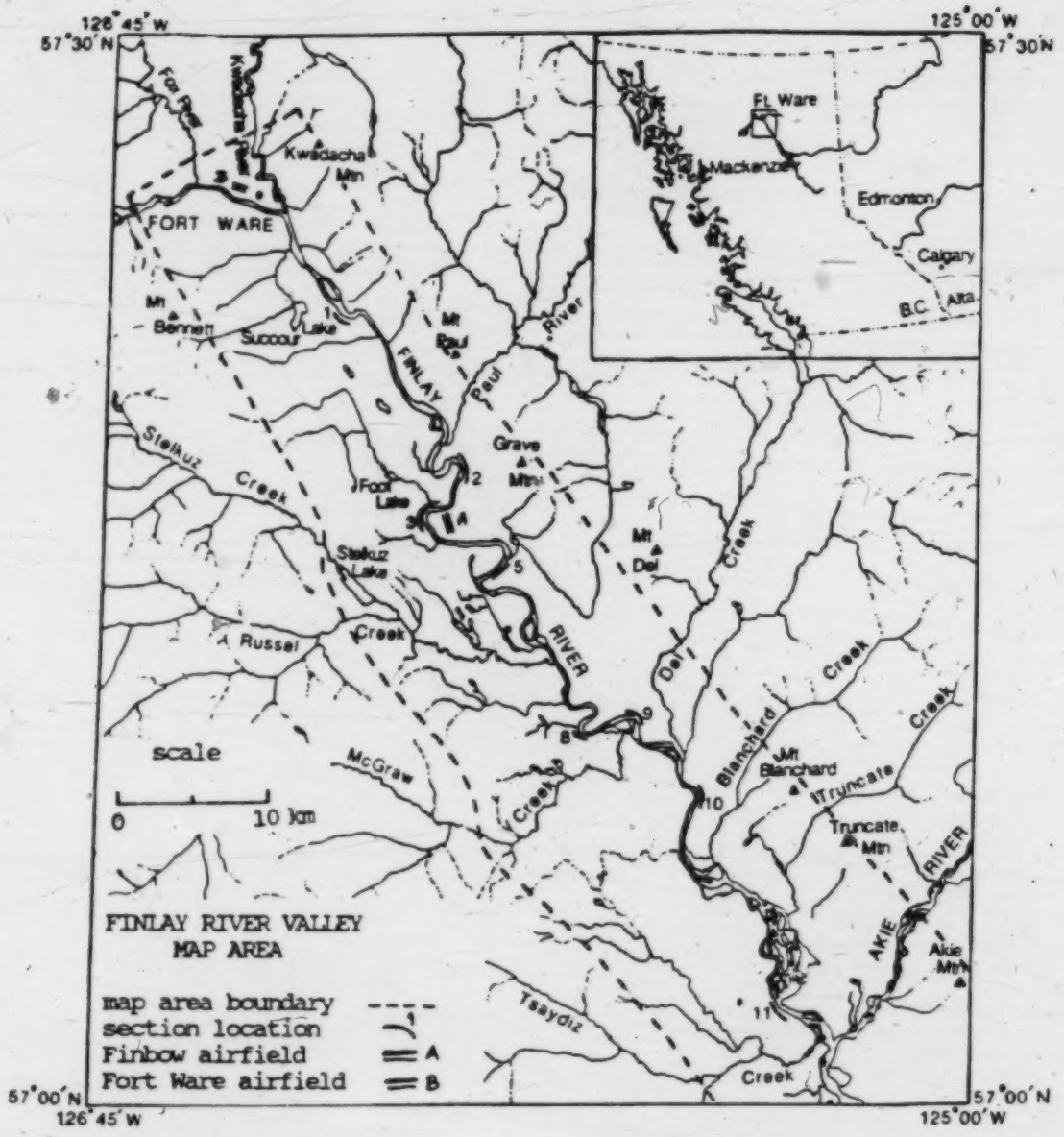


Figure 1.1 Location of map area and sections (modified from Ware 94F, Edition 1, 1:250,000, 1977)).

and 1600 m a.s.l. in the map area.

The Finlay River Valley is narrow (averaging 8 km wide) in the northern part of the map area between Fort Ware and the Finbow Airfield. South of this, the valley widens, averaging about 15 km wide. Drainage systems enter the valley from the east via Kwadacha, Paul, and Akie Rivers, and Del, Blanchard, and Truncate Creeks. The western tributaries include Finlay River and Russel, McGraw, and Tsaydiz Creeks. The Fox River flows within the Trench and enters the map area from the north. Thge Finlay River flows as a nearly straight river from where it enters the valley at Fort Ware to Paul River. It is both straight and meandering between Paul River and Blanchard Creek, and becomes braided from here to its confluence with the Akie River.

Climate and Vegetation

The Finlay River Valley occurs in a continental climatic region of long, cold winters and short, cool summers. Part of this region is in the rainshadow of the Coast Mountains and in some areas in the northern part where the Finlay River Valley occurs, the climate is significantly wetter than areas to the south (Ministry of Forest, British Columbia 1984). The precipitation record for Fort Ware, British Columbia between 1951 and 1980 is summarized in Table 1.1 (Environment Canada 1982).

The map area occurs within the northern region of the Interior Subalpine Forset area of British Columbia (Rowe 1972). North of 54°N latitude the forest cover is continuous across intervening valleys

Table 1.1 Precipitation record for Fort Ware, British Columbia (1951-1980) (modified from Environment Canada 1982).

FORT WARE
57° 26' N 125° 38' W 777 m a.s.l.

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Daily Maximum Temperature (°C)	-15.2	-6.4	1.0	7.8	14.7	19.4	21.0	20.1	14.3	6.0	-4.8	-11.3	5.6
Daily Minimum Temperature (°C)	-24.4	-17.8	-13.0	-5.3	-1.4	3.4	6.2	5.4	1.2	-3.7	-12.0	-19.0	-6.7
Daily Temperature (°C)	**-19.9**	**-12.1**	**-6.0**	**1.3**	**6.7**	**11.4**	**13.6**	**12.8**	**7.8**	**1.1**	**-8.4**	**-15.2**	**-0.6**
Standard Deviation, Daily Temperature(°C)	4.3	4.7	2.8	1.0	0.7	1.6	1.6	1.2	0.8	1.1	4.1	5.3	0.3
Extreme Maximum Temperature (°C)	3.9	5.6	11.1	22.8	27.8	33.3	30.0	31.0	27.2	16.7	10.6	2.8	33.3
(Years of Record)	(11)	(12)	(10)	(9)	(10)	(10)	(9)	(9)	(7)	(10)	(11)	(10)	
Extreme Minimum Temperature (°C)	-48.3	-44.0	-39.5	-20.6	-8.3	-4.4	-6.1	-3.5	-10.0	-21.7	-35.6	-45.6	-48.3
(Years of Record)	(12)	(12)	(10)	(9)	(9)	(10)	(9)	(10)	(7)	(11)	(12)	(11)	
Rainfall (mm)	0.0	0.9	0.1	6.5	32.2	43.6	68.8	49.0	42.3	18.3	1.3	38.1	301.2
Snowfall (mm)	42.1	30.3	13.7	6.9	0.1	0.0	0.0	0.0	1.2	9.2	36.0	47.0	186.5
Total Precipitation (mm)	**49.7**	**38.0**	**18.0**	**14.7**	**32.9**	**44.3**	**68.8**	**48.5**	**43.2**	**27.9**	**46.8**	**60.3**	**493.2**

consisting mostly of white and black spruce with associated alpine fir. Stands of lodgepole-pine grow in areas recently affected by catostrophic forest fires and are eventually succeeded by white spruce based on the geographic setting (Eyre 1980) of the Finlay River Valley area.

Bedrock Geology

The Northern Rocky Mountain Trench is bordered on the east by the Rocky Mountains, and on the west by the Finlay Ranges of the Omineca Mountains. The Rocky Mountains contain mostly carbonate rocks with some clastic rocks. These include rocks from the Upper Proterozoic and Lower Cambrian Misinchinka Group, the Upper Cambrian to Lower Ordovician Kechika Group, and the Ordovician to Silurian Road River Formation. Measurements on bedrock indicate dips to the east and west between 30 and 70° trending between 103 and 176° azimuth (Gabrielse n.d.). The Finlay Ranges consist of carbonate and clastic rocks of the Upper Cretaceous to Eocene Sifton Formation, the Upper Cambrian to Lower Ordovician Kechika Group, and the Upper Proterozoic Espee and Stelkuz Formations. Measurements on bedrock indicate dips to the west at angles between 30 and 70° with trends between 108 and 131° azimuth. Farther west, where the Kutcho and Finlay Faults occur, the bedrock consists predominantly of igneous, metamorphic, and volcanic rocks ranging from Lower Jurassic to Late Cretaceous. The area surrounding Lake Thatude, from where the Finlay River originates, consists of mostly clastic rocks of the Middle Jurassic to Lower Cretaceous

Bowser-Dewdney Assemblage (Figure 1.2).

The bedrock of the Trench floor consists primarily of Upper Cretaceous to Oligocene Brother's Peak Assemblage (Tipper et al 1981) which is characterized by sandstone, shale, conglomerate, coal, and acid tuff rocks. This assemblage is bounded by the Northern Rocky Mountain Trench Fault on the east, and by the McLeod Lake Fault on the west. Both faults are dextral translucent faults (Tipper et al 1981). The bedrock that borders these faults is the Proterozoic Windermere Formation consisting of an assemblage of sandstone, siltstone, shale, diamictite, limestone, basalt, iron formation, and pebble conglomerate. These form the mountains on the eastern and western edges of the map area.

SYMBOLS

Bedrock unit contact

Fault with sense of movement not indicated (approximate, assumed)

Dextral translucent fault

Fault with downthrow side indicated by solid circle

Thrust fault

map area

LEGEND

Bedrock units

1 mostly clastic rocks - includes Brothers Peak (Sifton Formation), Jackass Mountain-Skeena, Bowser-Dewdney, Earn-Black Clastic, and Gog Hamill (Atan Formation) Assemblages

2 mostly carbonate rocks - includes Karmutsen-Nikolai, Stikine-Asitka, and Main Ranges (Kechika and Road River Formations) Assemblages

3 mostly igneous and metamorphic rocks - includes Archean gneiss, and all plutonic and ultramafic rocks

4 volcanics mixed with clastic and carbonate rocks - includes Hazelton-Bonanza and Takla-Nicola Assemblages

5 mixed clastic and carbonate rocks - includes Slide Mountain-Sylvester, Windermere (Espee, Stelkuz, and Misinchinka Formations), and Mackenzie-Muskwa Assemblages

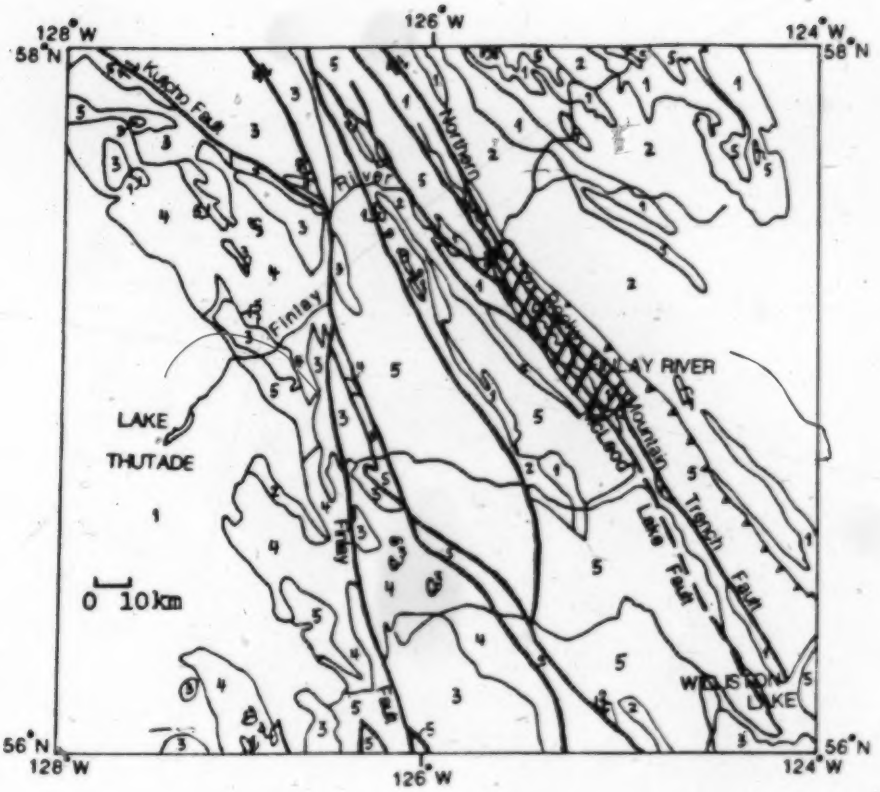


Figure 1.2 Regional bedrock geology (modified from Tipper et al 1981).

B. PREVIOUS WORK

The Northern Rocky Mountain Trench was first explored as early as 1824 by Samuel Black and later on by Dawson (1888) and McConnell (1896). It was not until the proposal for the hydroelectric dam near Hudson Hope in 1966 that a detailed investigation of the glacial geology of the Trench occurred (Rutter and Taylor 1968). The NTS 94C map sheet, which lies directly to the south of the map area was surveyed by Rutter (1977a) from 1966 to 1969 from which a surficial map was compiled (GSC map 1381A,1977).

Rutter (1977a) recognized surficial deposits of Late Wisconsinan in age to have originated from three glacial advances; Early Portage Mountain, Late Portage Mountain and Deserter's Canyon. Deposits from Early Portage Mountain advance occur as surface deposits only above 1060 m (3500 feet) elevation. The last major glaciation to affect the area was the Late Portage Mountain advance, represented by widespread till, drumlins, an end moraine complex near Portage Mountain, and abandoned ice-marginal channels below 1060 m (3500 feet) elevation. The glacier ice was generally topographically controlled during this event, as indicated by drumlins, hummocks, and glaciofluvial ice-contact deposits such as kames, pits and eskers. The Deserter's Canyon advance was less extensive, originating from Cassiar and Omineca Mountains. Evidence for this event consists of an end moraine which is located along the west side of the Finlay River Valley, and fresh lateral moraines found up to 910 m (3000 feet) elevation to the east in Barrier Pass. Post-glacial deposits primarily occur in the form of terraces,

generally less than 15 m above the floodplain. Recent deposits include floodplain and associated deposits as well as alluvial fans, eolian, slump, colluviated and organic deposits.

Bobrowsky (et al 1987) observed no evidence from his work in the Finlay River Valley for the Deserter's Canyon Advance (Rutter 1977a). He places the uppermost diamicton unit, referred to by Rutter (1977a) as the Portage Mountain Advance in Late Wisconsinan.

Mathews (1980) identified minor abandoned channels and ice-directional features as indicated by drumlins and grooves in the map area. Mathews also located extensive glaciolacustrine deposits east of the study area, formed by ice-dammed lakes in major eastern tributaries.

C. METHODS OF INVESTIGATION

INTRODUCTION

Surficial deposits and landforms of the Finlay River Valley were examined during the summers of 1984 and 1985. The methods used to investigate the surficial deposits and landforms of the map area were field descriptions, pebble fabric analysis, grain size analysis, pebble lithology, and airphoto interpretation. Deposits of particular interest include an uppermost late glacial diamicton, glaciofluvial, glaciolacustrine, and Recent deposits. Most deposits are exposed along the cut bank of the Finlay River.

FIELD DESCRIPTIONS

Descriptions of surface and near surface deposits were made at 8 sections (Figure 1.1). The exposures vary from 200 m high and over 1 km long, to small river bank terraces 6 m in height and 100 m long. A systematic field description was carried out at each site investigated to ensure consistency and completeness of observations. Field descriptions incuded the following:

1. Munsell colour;
2. estimated percent of clast content (>1 cm in diameter);
3. clast shape and roundness (Powers 1953);
4. unit thickness;
5. degree of sorting (Compton 1962);
6. size, type, extent, and prevalence of primary sedimentary features

7. nature of upper and lower contacts;
8. vertical and lateral changes;
9. fault and joint patterns;
10. presence of organic material; and
11. weathering characteristics.

PEBBLE FABRIC ANALYSIS

Pebble fabric analyses were performed on the uppermost late glacial diamicton unit at several localities by measuring the trend and plunge of 50 pebbles consisting of a long axis of at least 2 cm in length, and with generally prolate to blade shapes. There were relatively few large clasts (>5 cm in diameter) of these shapes, and for this reason small pebbles (2 to 4 cm in diameter) were included in the analysis. Fabric measurements were sampled within a horizontal plane of an area of approximately 50 cm^2. Pebble fabrics provided a part of the description of individual units and use as an aid in determining the mode of deposition of the diamicton.

Fabric data were statistically analyzed using a microcomputer program (Charlesworth et al in press) to determine the degree and orientation of three modes of clustering represented by eigenvalues and eigenvectors (S_1, S_2, and S_3, and V_1, V_2, and V_3 (Mark 1974)). Calculations for all pebble fabric measurements are included in Appendix I. In addition, the microcomputer program illustrates the results in both 2 and 3 dimensional orientation diagrams. The program is similar to one that has been developed by Mark (1971; 1973). Two

dimensional orientation diagrams are represented by symetrical smoothed rose diagrams with a smoothing parameter of 100. Three-dimensional orientation diagrams are represented by probability contour plots. The probability parameter which best represented most fabric patterns was found to be 100 (Figure 1.3). The size of the counting circle was determined to be 2% of the area of the projection circle (Cheeney 1983).

GRAIN SIZE ANALYSIS

Grain size analysis was primarily carried out to describe an individual unit. Vertical sequences of samples were taken at several localities to determine if the grain size was related to the vertical position in the unit sampled. The hydrometer method as described in ASTM D423 (1964) was used to analyse the matrix texture of the clast portion of grain sizes of the uppermost diamicton units <2 mm in diameter. The fraction >0.0625 mm was sieved according to the procedures given in ASTM D422 (1964). The combined hydrometer and sieve data were analysed using a computer program developed by D. Wynn (Department of Geology, University of Alberta, Edmonton, Alberta). The program calculates sand, silt, and clay percents, and statistical grain size parameters after the formulas given in Folk (1980) based on the combined hydrometer-sieve results. The grain size analysis calculations are given in Appendix II.

K=50

K=100

K=150

sample: F27
Section: 8
V_1(trend): 342°
V_1(plunge): 6.4°
S_1(eigenvalue): 0.84

Figure 1.3 Comparison of three probability parameters (K) using an example of a Type 1A Diamicton sample.

PEBBLE LITHOLOGY

Pebble lithology was conducted to determine the origin of the large clasts occurring in the diamicton units. Pebble samples were collected from the uppermost diamicton units at several localities. The lithology of a random selection of a minimum of 50 medium to large pebbles (8 to 64 mm in diameter) was identified in the field. Three lithologic groups are represented by carbonate, clastic, and igneous and metamorphic. Carbonate rocks generally indicate a distal eastern source, clastic rocks indicate a local source, and igneous and metamorphic rocks generally indicate a distal western source. The results of pebble lithology analysis are given in Appendix III.

AIRPHOTO INTERPRETATION

Identification of surficial landforms and deposits was completed through airphoto interpretation. Several sets of airphotos taken between 1949 and 1985, and ranging in scale from 1:20,000 to 1:60,000 were used. Good quality airphotos allowed for the identification of major deposits based on the photographic tone which was found to be related to the type of vegetative cover.

The major deposit types such as morainal, glaciofluvial, and fluvial, were identified on airphotos after being observed in vertical sections along the Finlay River. Morainal deposits generally have dark tones (Plate 1.1) due to a vegetative cover consisting predominantly of a mature black and white spruce forest and associated alpine fir. No distinction was made between spruce and alpine fir tree types. Areas

recently affected by forest fires have light smooth tones indicating the presence of pioneer lodgepole-pine dominated forest (Plate 1.2). In all cases the forest fire areas are indicated by irregular borders of abrupt changes in vegetation. Deposits which occur in the morainal, M, map unit composed of sandy till, ts, have a mixture of light and dark tones (Plate 1.1). The light tones are represented by a variety of dense pine stands and grassland or shrubbed areas. This vegetation occurs where the surficial deposits consist mostly of sand and gravel. Hence, the dark tones represented by spruce and fir indicate areas where diamicton deposits occur at the surface.

Glaciofluvial deposits are represented by mappable areas of light tones. The vegetation cover is similar to sand and gravel deposits in morainal, M, map units composed of sandy till, ts, (Plate 1.3). The amount of spruce and fir occurring with glaciofluvial units is much less and more scattered than morainal units.

Most fluvial units are represented by dark-toned floodplain deposits (Plate 1.1). The vegetative cover on the deposits are predominantly black spruce commonly associated with wet areas.

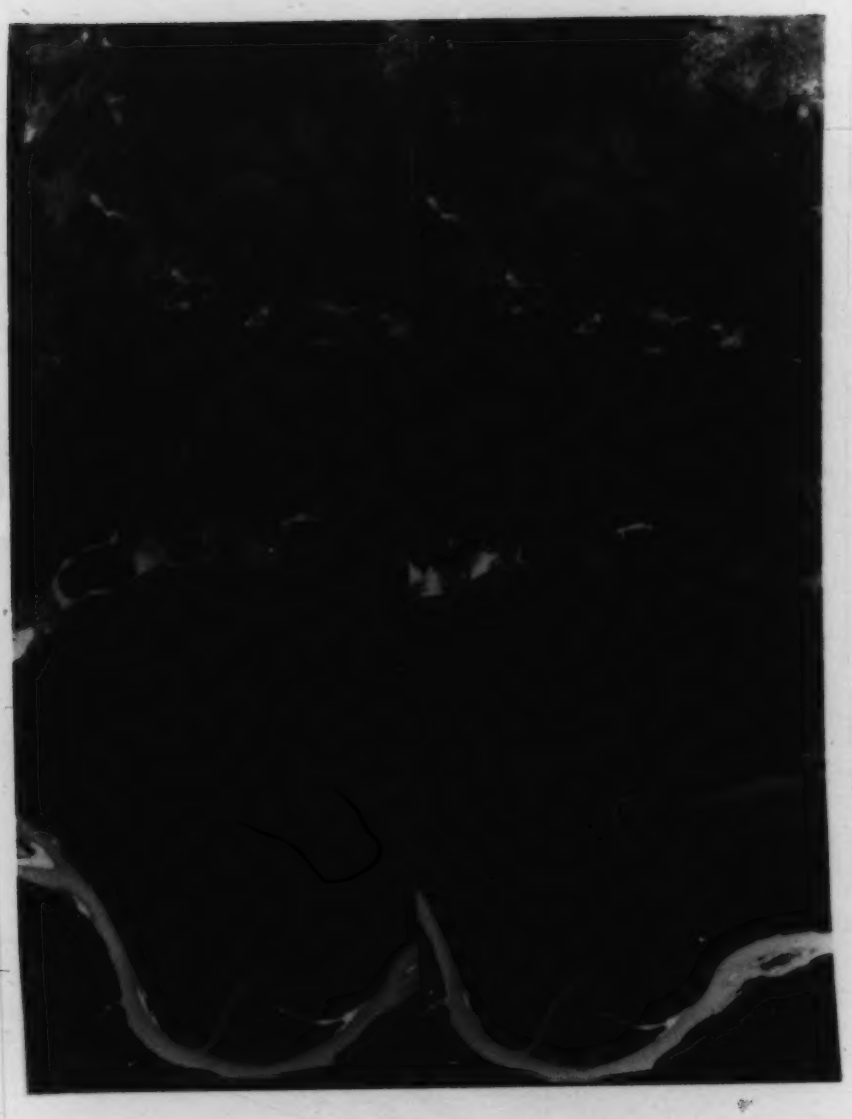


Plate 1.1 Airphoto set illustrating tonal variation between morainal map units composed of till, t (1), and sandy till, ts (2). Also, note the dark tone of floodplain deposits (3). (Scale 1:60,000)

Plate 1.2 Airphoto set of forest fires indicated by tonal variations: oldest vegetation (1); old forest fire (2); and young forest fire (3). (Scale 1:60,000)

Plate 1.3 Airphoto set illustrating tonal variations of a sandy glaciofluvial map unit (1), a morainal unit composed of sandy till (2), and an undivided glaciolacustrine and glaciofluvial map unit (3). (Scale 1:60,000)

CHAPTER 2

The classification scheme used for this map area is a modification of that proposed by Rutter (1977b) and Canada Soil Survey Committee (1978). It is based on four elements; composition, genetic class, genetic modifier, and morphology. The surficial deposits are discussed as they occur in the map legend from oldest to youngest deposits. Pleistocene deposits are divided into three genetic classes; morainal, glaciolacustrine, and glaciofluvial. Holocene deposits include the genetic classes; fluvial, alluvial, and organic.

A. PLEISTOCENE DEPOSITS

Pleistocene deposits occur throughout the map area and comprise the majority of surficial deposits. All deposits occur at an elevation greater than approximately 20 m above the Finlay River level.

MORAINAL DEPOSITS

Morainal deposits represent about 70% of the exposed surface deposits of the map area and have a variety of compositions and morphology. There are nine categories of morainal deposits. The morainal, M, map unit is the most frequently exposed map unit both on the surface and along the cut bank of the Finlay River. Although this map unit is described briefly in this chapter, a detailed description and interpretation of the deposits are discussed in Chapter 3. All morainal deposits are represented by the compositional unit, t,

referred to as till which is equivalent to a diamicton texture.

i. Morainal & Grooved Morainal Deposits Overlying Bedrock Map Units (M/B & MU/B)

Morainal deposits which are thin (<1 m) to discontinuous and where the morphology is predominantly controlled by underlying bedrock are mapped as morainal and grooved morainal deposits overlying bedrock, M/B and MU/B, map units. These units are not exposed in vertical section. The most common map unit is ridged morainal till overlying bedrock, tMr/B, which usually consists of small, isolated, ridges and pyramid-shaped hills (Plate 2.1). This unit occurs on the western side of the valley in the vicinity of Russel Creek and at the northern end of the valley on both sides of the Finlay River. Rolling and drumlinoid morphology are also present and occur directly north of Tsaydiz Creek. Alignment of the drumlins appears to follow the strike of the bedrock in the area.

Grooved morainal deposit overlying bedrock, MU/B, map unit occurs on the southern, lee-side slope of a bedrock high directly east of Stelkuz Lake. Grooves are elongated, straight, narrow depressions oriented closely parallel to the valley trend. They are approximately 500 m to 3 km long, and 10 to 30 m deep, and indicate that the ice-flow direction was probably down-valley at about 135^{o} azimuth (Plate 2.2).

ii. Morainal & Dissected Morainal Stagnant Ice Map Units (MSI & MSID)

Photographically dark-toned units with ridged and hummocky to

Plate 2.1 Airphoto set of till morainal ridged deposit overlying bedrock map unit, tMr/B (1). (Scale 1:60,000)

Plate 2.2 Airphoto set of grooved bedrock, BU (1), and grooved morainal deposit overlying bedrock, MU/B (2) map units. (Scale 1:60,000)

rolling surfaces are mapped as morainal and dissected morainal stagnant-ice, MSI and MSID, map units. They are not exposed in vertical section, and occur within a valley-marginal channel located on the western edge of the map area, between McGraw and Tsaydiz Creeks. These morainal units are recognized as stagnant-ice deposits on the basis of the hummocky to rolling morphology (Plate 2.3). Areas where gullying occurs more frequently are mapped as MSID unit. The MSI unit has greater surface relief and contains one isolated esker ridge.

iii. Undivided Morainal and Glaciofluvial Ice-Contact Map Unit (MGIC)

An isolated, photographically dark-toned, ridged deposit is mapped as the undivided morainal and glaciofluvial ice-contact, MGIC, map unit. The unit occurs on the western slope of the valley directly north of McGraw Creek, and is not exposed in vertical section. The surface morphology is mostly rolling with elongated esker ridges. The eskers are slightly sinuous and are oriented both downslope and transverse to slope. They range in length from approximately 0.5 to 1.5 km in length and 30 m high.

iv. Dissected Morainal Map Unit (MD)

A photographically dark-toned area modified by narrow, parallel gullying is mapped as the dissected morainal, MD, map unit. The unit occurs within the broad till plain, directly south of Russel Creek, and is not exposed in vertical section. The unit has well defined gullies, moderate surface relief, and a slightly mottled photographic texture.

Plate 2.3 Airphoto set of drumlins (1) and map units morainal stagnant-ice, MSI (2), and dissected morainal stagnant-ice, MSID (3). (Scale 1:60,000)

Minor meltwater channels are narrow, generally deep sinuous depressions not longer than approximately 1.5 km. The flow direction indicated by the map symbol is determined by the downslope direction.

v. Colluviated Morainal Map Unit (MC)

A colluvial cover that drapes most slopes along the Finlay River valley is mapped as the colluviated morainal, MC, map unit. This unit is partially exposed in slumps located along a north-south road south of Grave Mountain. It appears to have a high clay and silt content, which makes the material susceptible to slumping.

vi. Undivided Morainal and Organic Map Unit (MO)

Flat-lying morainal deposits occurring in depressions are mapped as the undivided morainal and organic, MO, map unit. The unit is not exposed in vertical section and occurs where drumlins are separated by poorly drained low-lying areas. These areas are located directly south of Mount Bennett, and adjacent to the drumlinoid till plain directly south of Russel Creek. The drumlins have a similar morphology to those which occur with the morainal, M, map unit described below.

vii. Morainal Map Unit (M)

Morainal, M, map unit is widely distributed throughout the map area. The map unit compositions are till, t, and sandy till, ts. The till map unit is photographically darker-toned and is exposed at Sections 8, 10, and 11. The morainal map unit composed of till consists

of thick (>8 m) diamicton deposits which are laterally extensive (>1 km) in exposed river sections. The slightly lighter-toned sandy till map unit consists of pockets of discontinuous sand and gravel, and diamicton deposits. The sandy till map unit is exposed at Sections 1, 2, 3, 5, and 9. The sand component of this map unit is due to the occurrence of sand and gravel deposits and the till component from diamicton deposits exposed on the surface. They are mapped as one unit because the two deposits cannot be separated on the scale of mapping. The diamicton deposits of the sandy till map unit are similar in texture to the diamicton deposits of the till map unit. Thickness of the diamicton deposits in the sandy till unit vary from 2 to 12 m, and have a lateral extent ranging from 2 to 300 m.

The morphology of till and sandy till units are commonly plain to rolling and occur distributed throughout the map area. In some areas the till map unit has kettled to rolling and drumlinoid morphologies. The kettled to rolling (km) morphology occurs on the north bank of the Akie River, and is the only morainal map unit not observed in vertical section.

Drumlinoid morphology consists of ellipsoid to elongate-shaped, positive relief features, oriented parallel to the valley trend. They occur mostly on the west side of the valley, south of Russel Creek (Plate 2.3). Isolated occurrences are located directly southeast of Mount Bennett and on the east side of the valley, on the southern slope of Grave Mountain. The drumlins are of similar character throughout the valley. They are between approximately 200 and 800 m in length and 30

and 50 m in height. Drumlins exposed in vertical section along McGraw Creek are composed of till. They can occur as a single well-defined drumlin, or side-by-side as pairs or triplets, forming irregular to circular topographic highs. The ice-flow direction of drumlins located on the west side of the valley south of Russel Creek trend down-valley at about 140° azimuth. Those southeast of Mount Bennett trend down-valley at about 170° azimuth.

GLACIOLACUSTRINE DEPOSITS

i. Undivided Glaciolacustrine and Glaciofluvial Map Unit (LG)

Deposits that cannot readily be defined as either glaciolacustrine or glaciofluvial are mapped as the undivided glaciolacustrine and glaciofluvial, LG, map unit. The unit is not exposed in vertical section and occurs within isolated, relatively small, depressions bordering laterally extensive organic deposits. They are located in the northern part of the map, bordering Succour Lake and an unnamed lake, 2 km to the south, as well as in the southern part of the map, directly north of Tsaydiz Creek. Although the photographic tone is similar to that of morainal deposits, the flat surface morphology suggests that the unit is not a morainal unit. Based on the dark tone, the deposits are probably composed of fine sand, silt, and clay.

GLACIOFLUVIAL DEPOSITS

i. Glaciofluvial Ice-Contact Map Unit (GIC)

Photographically light-toned areas with ridged features are mapped as the glaciofluvial ice-contact, GIC, map unit. The unit is not exposed in vertical section. It is represented by extensive, well defined eskers, and a pitted surface (Plate 2.4). The unit is typically found adjacent to the morainal stagnant-ice, MSI, map unit and is located within a valley-marginal channel on the western edge of the map, between McGraw and Tsaydiz Creeks. An isolated exposure of the map unit is also located directly north of Stelkuz Lake.

Eskers are narrow, elongated positive relief features approximately 30 m high and 500 m to 2.5 km in length. They are straight to slightly sinuous. Some form single ridges whereas others branch off into pairs or join together to form one ridge. The topographic expressions of most eskers indicate flow directions oriented down-valley. Some esker flow directions cannot be determined through airphoto analysis. Light photographic tones, represented probably by a pine dominated forest, indicate that the eskers are composed generally of sand and gravel.

ii. Undivided Glaciofluvial and Organic Map Unit (GO)

Two large meltwater channels containing small pockets of organic deposits bordered by glaciofluvial deposits are mapped as the undivided glaciofluvial and organic, GO, map unit. The unit was not observed in vertical section. The meltwater channels are located on the west side

Plate 2.4 Airphoto set of sandy glaciofluvial ice-contact ridged to pitted, sGICrpi (1), and ridged, sGICr (2). (Scale 1:60,000)

of the valley approximately 1 km southwest of Foot Lake and on the east side of the valley between Blanchard and Truncate Creeks. Dark photographic tones represented by spruce indicate a moist soil similar to floodplain deposits that consist of silt, sand and gravel sediments.

iii. Glaciofluvial Map Unit (G)

Glaciofluvial, G, map unit comprises 5 to 10% of the surficial deposits in the Finlay River Valley. The unit has light photographic tones, and occurs scattered throughout the map area in large meltwater channels and bordering morainal deposits. The surface morphology includes flat, pitted, rolling, and veneered areas.

The thickness of glaciofluvial sediments varies from <2 to 15 m. These sediments consist of poorly to well sorted gravel and sand. Stratification present includes trough-cross beds, planar-tabular cross-beds, wavy beds, and massive beds with discontinuous interbeds of horizontally bedded and wavy bedded silt. The gravel consists of subrounded to rounded pebbles (2 to 5 cm in diameter) of various lithologic compositions.

Meltwater channels which have glaciofluvial deposits in their bottoms are sinuous, negative relief features ranging from approximately 50 m to 1 km in width. They are widely distributed and a common landform in the Finlay River Valley. They are approximately 40 to 60 m deep and 1 to 15 km in length. The widest channel occurs adjacent to the eastern slope of the valley south of Paul River (Plate 2.5). The longest channels occur on the western edge of the map area

Plate 2.5 Airphoto set of a large meltwater channel (1) near Section 9 (2). (Scale 1:60,000)

along and south of McGraw Creek. Smaller and shallower meltwater channels are not indicated as a separate map unit, but can be expected to consist of deposits similar to those which occur in the larger meltwater channels.

B. HOLOCENE DEPOSITS

Holocene deposits, primarily represented by fluvial floodplain and terrace deposits, comprise a small percentage of the total surficial deposits. Less abundant are organic and alluvial deposits that occur scattered throughout the Finlay River Valley. Fluvial deposits generally occur adjacent to the rivers and creeks of the area at an elevation less than approximately 20 m above the river level.

i. Fluvial Deposits (F)

Fluvial deposits represent the majority of non-glacial, surficial deposits bordering the major rivers and creeks of the Finlay River Valley. Many are exposed in cut bank sections and occur at elevations less than approximately 20 m above the river level. They are composed of various grain sizes, dominated by sand and gravel. Fluvial deposits also occur in the channel bottoms of larger meltwater channels which support creeks. Dark photographic tones and slightly mottled texture of these channel bottoms have similar photographic characteristics to floodplain deposits found adjacent to the Finlay River. Hence, channel bottoms probably consist of sand and silt, with some gravel. The morphology varies through plain, rolling, terraced, and meander-scrolled. Fluvial deposits are separated into terrace, floodplain, and other fluvial deposits.

a) Terrace deposits

Three distinct terrace levels are present along the Finlay River at heights between 4 and 12 m above the river level (Plate 2.6). The

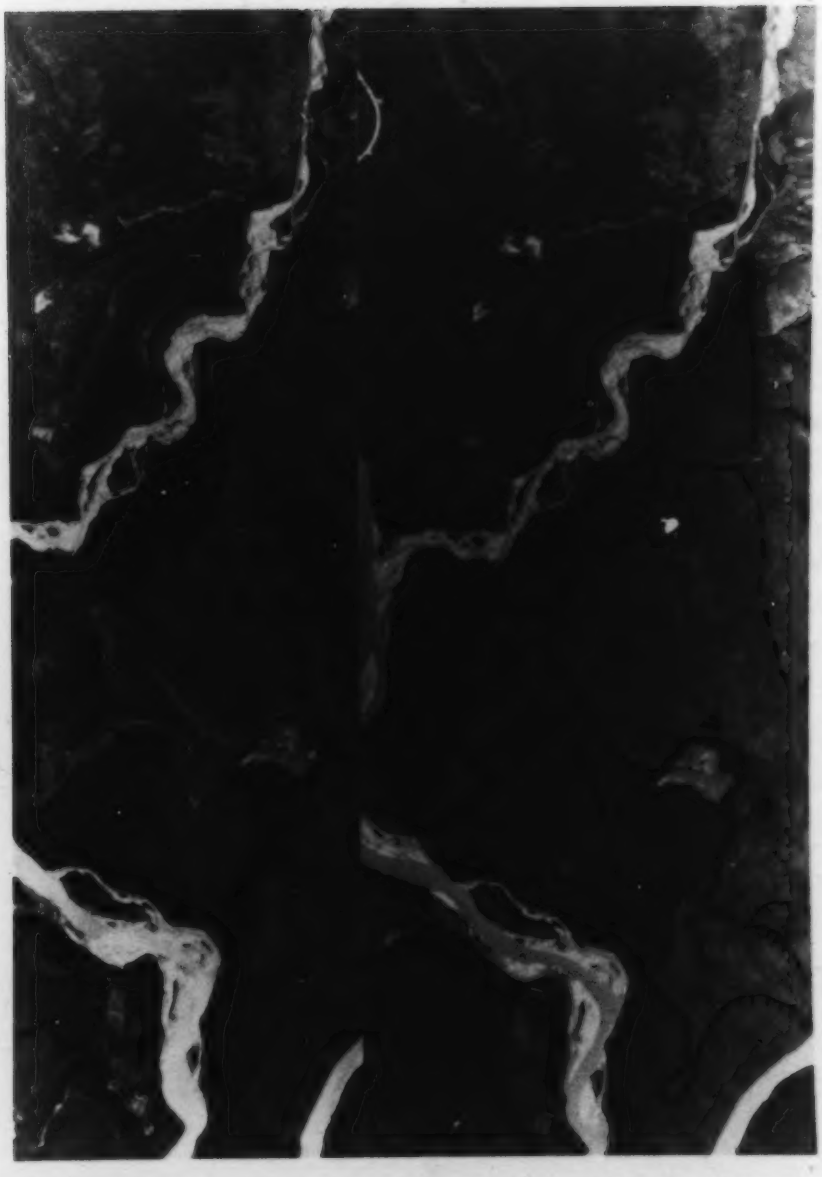


Plate 2.6 Airphoto set of fluvial terrace levels: t_1, 4-6 m (1); t_2, 8-10 m (2); and t_3, 12 m (3). (Scale 1:60,000)

most widely distributed terraces are t_1 (4 to 6 m) and t_2 (8 to 10 m) levels, with t_3 (12 m) restricted to areas directly adjacent to tributaries.

The surface morphology of the two lower levels is generally flat, with a veneer (<1 m thick) of silt and fine sand overbank deposits. Surfaces of the t_1 level also show meander scrolls and abandoned creek channels. The surfaces of t_3 level are flat to rolling, and are usually capped by a very thin and discontinuous veneer of silt.

Vertical exposures of fluvial sediments occur frequently along the cut banks of the Finlay River. The fluvial sediments are composed of four distinct units: overbank sediments, channel fill sediments, channel bar sediments, and lag gravel (Figure 2.1). Remnant till blocks, lake sediments, and deformed, cemented gravels can occur in the core of the terraces. The overbank sediments consist of thinly interbedded and laminated, well sorted silt and fine to medium sand. Bedding is frequently moderately defined to very distinct. Clearly defined wavy and horizontal beds, as well as planar-tabular cross-beds are also present. Gravel is interbedded with fine to medium sand at some sites. Sediments are commonly thickest (2 to 3 m) capping t_1 terrace, and discontinuous to absent on the higher terraces.

Channel fill, channel bar, and lag gravel are closely associated and are commonly exposed in the t_2 and t_3 terraces. The lag gravel unit consists of a layer of subrounded to rounded large pebbles to medium cobbles (5 to 10 cm in diameter) and, less frequently, large subrounded cobbles (15 to 20 cm in diameter). This unit marks the

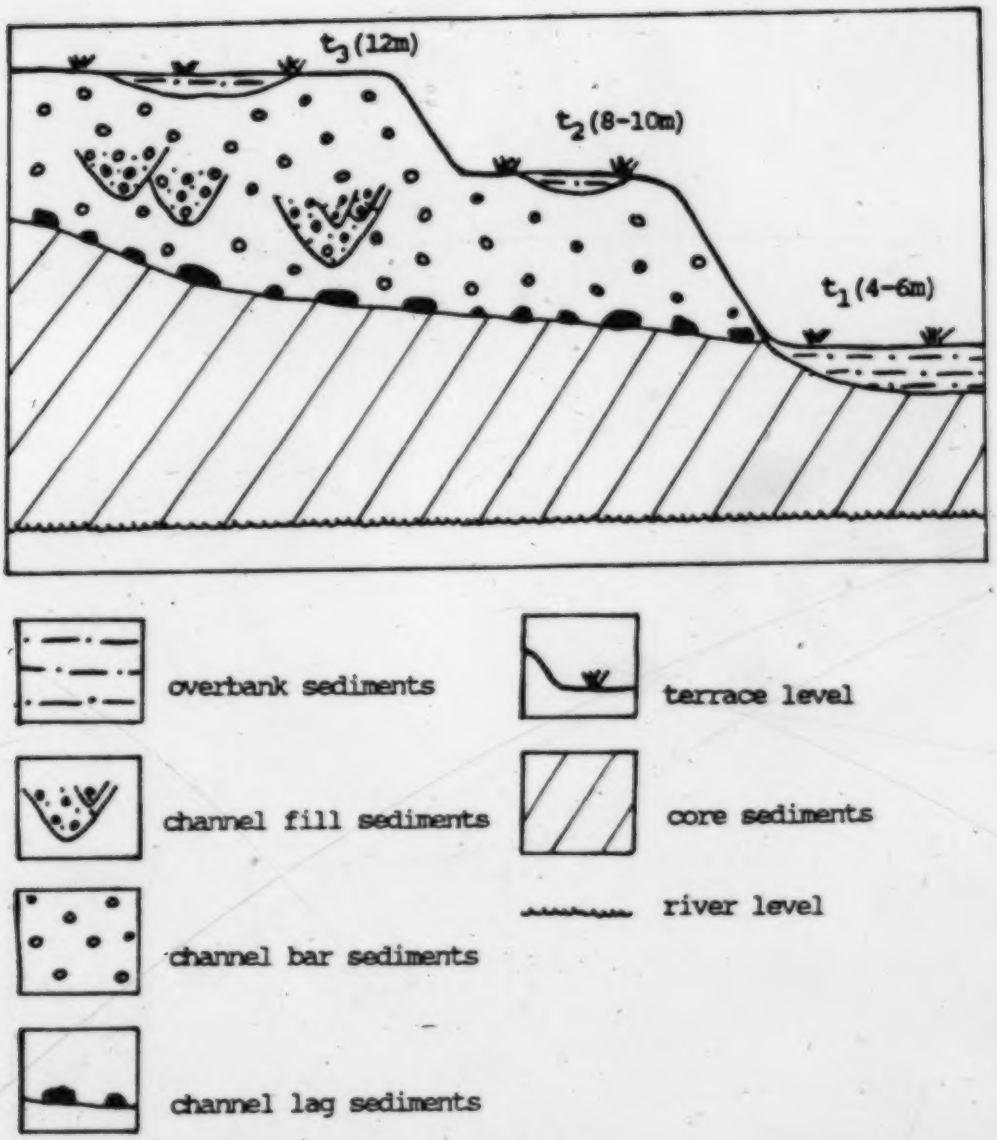


Figure 2.1 Lithologic units of terrace deposits.

channel bottom and also the base of terrace construction. The unbedded channel fill unit occurs typically as cut and fill features, whereas the channel bar unit is represented by crudely horizontally bedded to unbedded sand and gravel. Both units consist of 50 to 55% coarse to medium sand matrix with subrounded to subangular large pebbles (2 to 5 cm in diameter). The gravels are poorly to moderately sorted, with a general fining upwards in the upper 2 m of the exposed unit. An abrupt upward transition from horizontal thin beds of gravel to medium to fine sand was observed. The total thickness of t_3 terrace remnants of the channel fill and channel bar sediments ranges from 2 to 6 m, averaging about 4 m. Thicknesses of t_2 terrace range from 2 to 4 m, averaging about 2.5 m.

b) Floodplain deposits

Floodplain deposits occur along the banks of most of the rivers and creeks of the area, generally at elevations <4 m (averaging approximately 3 m) above the river level. The banks of the Finlay River and some of the larger islands of the river are vegetated, semi-permanent, and only rarely inundated. The most extensive floodplain occurs along the Finlay River between McGraw and Tsaydiz Creeks, where it is braided. The width of the Finlay River floodplain is a maximum of approximately 3 km, averaging 1.5 km. Within the map area, the Akie River also has a wide floodplain averaging about 1.5 km. Some floodplain deposits of the Finlay River, between Russel and Tsaydiz Creeks, have meander-scrolled surfaces.

Floodplain deposits consist of fine to medium sand with interbeds

of silt, and in some places discontinuous thin beds or lenses of medium sand-supported gravel. The silt and sand beds are commonly well sorted with horizontal to wavy beds averaging about 2 to 4 cm in thickness. The gravel is composed of subrounded to rounded pebbles, and is locally oxidized.

c) Other fluvial deposits

Isolated fluvial deposits which are at elevations approximately between 12 and 20 m above the river level occur along Finlay, Akie, and Fox Rivers and Russel Creek. The unit was not observed in vertical section. Light photographic tones similar to those of glaciofluvial deposits indicate that this deposit is composed mostly of sand and gravel. The surface morphology varies from flat to rolling.

ii. Alluvial Fan Deposits (A)

Alluvial fan deposits are generally represented by large, inactive, well developed alluvial fans. They occur along the eastern slope of Mount Bennett (Plate 2.7), and were not observed in vertical section. Smaller and less well developed fans occur to the south on both sides of the Finlay River valley, at the base of cliffs. It is assumed that they are composed mostly of gravel and sand (Ryder 1971).

iii. Organic Deposits (O)

Organic deposits occur in irregular depressions, presumably overlying fine grained sediments. They are found throughout the map area and are composed of muck, mucky peat, peat, and marl as well as

Plate 2.7 Airphoto set of the sandy gravel alluvial fan map unit, gsAf (1). (Scale 1:60,000)

fine sand, silt, and clay.

CHAPTER 3

A. DESCRIPTION AND INTERPRETATION OF MORAINAL DEPOSITS (M)

Surficial morainal deposits exposed along the Finlay River are grouped into two major diamicton types. Type 1 Diamicton, interpreted to be subglacial till, is massive with ordered fabric and contains no sorted material. Variations of Type 1 Diamicton include Types 1A and 1B. Type 1A Diamicton, interpreted to be lodgment till, has the same general characteristics as Type 1 Diamicton and in addition has fissility. Massive, coarse diamicton containing sand and gravel lenses is interpreted to be a modified subglacial meltout till and is designated as Type 1B Diamicton. The second major group is Type 2 Diamicton, which consists of interstratified diamicton beds and sand and gravel sediments, is interpreted to be debris flow deposits.

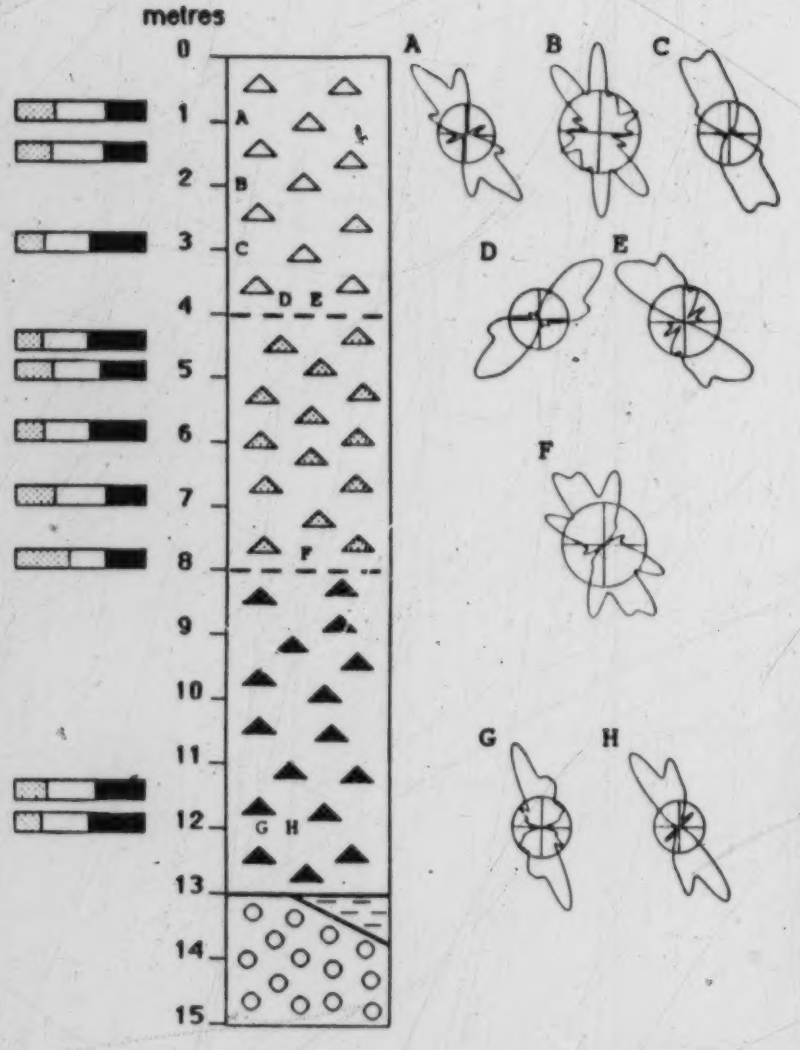
TYPE 1 DIAMICTON - DESCRIPTION

Massive diamicton deposits which do not contain sand and gravel lenses are designated as Type 1 Diamicton (Table 3.1). These deposits are exposed as the uppermost unit in the central part of Sections 1, 2 and 3, the downstream part of Section 5, and throughout Section 10 (Figure 3.1). Type 1 Diamicton occurs directly underlying Type 1B Diamicton (discussed on p.60 of this chapter) in the upstream part of Section 5 and throughout Section 11.

Type 1 Diamicton occurs with map units tsMp, tsMm, and tsMpm at Sections 1, 2, 3, and 5, and with map unit tMp at Section

TABLE 3.1 Summary data of diamicton types

DIAMICTON TYPE	1	1A	1B	2
DESCRIPTION	massive diamicton	diamicton with fissility	coarse diamicton with preserved sand & gravel lenses	coarse diamicton interstratified with sand & gravel sediments
SECTION LOCATION	1,2,3,5, 10 & 11	5 & 8	5 & 11	9
FABRIC PATTERN	unimodal to bimodal, & some polymodal	strongly unimodal	unimodal & polymodal	unimodal & some polymodal
S1 VALUE	0.48 - 0.77 mean = 0.65 (N=17)	0.73 - 0.84 (N=2)	0.67 - 0.77 (N=2)	0.48 - 0.85 mean = 0.70 (N=7)
BASAL CONTACTS	sharp, & irregular to planar	covered	sharp to gradational, & irregular to planar	sharp & planar
MATRIX TEXTURE sand (%) (max min mean) clay (%) (max min mean)	(N = 7) 57 39 46 24 13 18	(N = 3) 47 34 42 24 17 20	(N = 4) 32 25 29 37 32 34	(N = 46) 43 22 32 42 17 32
DIAGNOSTIC FEATURES	-massive texture -ordered fabric -lack of sorted sediments	-fissility -well ordered fabric	-preserved sand & gravel lenses at base of unit -coarse diamicton	-locally variable fabric orientations -diamicton inter-stratified with sand & gravel sediments -geometry of diamicton beds
INTERPRETATION	subglacial till	lodgment till	modified subglacial meltout till	debris flow deposits



sample	V_1 (trend)°	V_1 (plunge)°	S_1 (eigenvalue)
A	146	6.1	0.72
B	344	4.2	0.57
C	338	15.0	0.76
D	056	0.3	0.71
E	334	10.4	0.70
F	332	4.0	0.64
G	353	11.2	0.69
H	341	8.1	0.70

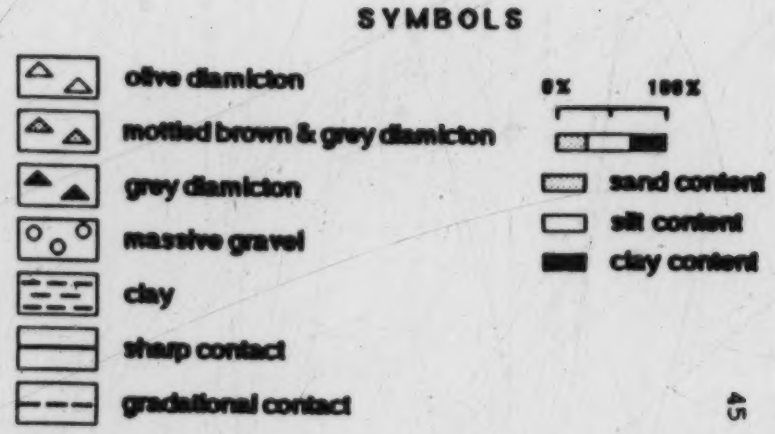


Figure 3.1 Summary data of Type 1 Diamicton (Section 10)

10. At Section 11, Type 1 Diamicton is not exposed at the surface. At all exposures the internal characteristics of the diamicton are similar. The compositional difference, indicated by the compositional unit, s, is dependent on the lateral extent of the diamicton. Map unit composed of ts indicate that the diamicton is laterally discontinuous. In all of these cases, sand and gravel sediments occur at the surface alongside diamicton units and are represented by the compositional unit, s, indicating sand. Therefore, the map unit represents the surface distribution of two units and does not reflect the internal composition of the diamicton unit exposed at the surface. The surface morphology of the diamicton unit is similar at all section locations. The thickness of Type 1 Diamicton at Sections 1, 2, 3, and 5 ranges between 5 and 12 m, whereas at Section 10, the thickness is approximately 20 m throughout.

In most cases, Type 1 Diamicton consists of four zones: an upper, 4 to 5 m thick, olive-brown (5Y4/3 dry to 2.5Y5/4 and 2.5Y3/2 wet) zone; a middle, 1.5 to 4 m thick, mottled brown and grey zone; a lower, 5 to 15 m thick, dark grey (5Y5/1 dry to 5Y3/1 wet) zone; and a lowermost 30 to 50 cm thick, greyish brown (2.5Y3/2 wet) zone. Contacts between zones are irregular and gradational. In the downstream part of Section 5 where Type 1 Diamicton is approximately 5 m thick, it consists of a single olive-brown (5Y4/3 dry to 2.5Y4/4 wet) zone.

Subangular to subrounded clasts range from 2 to 7 cm in diameter and form 30 to 45% of the unit. The diamicton is not graded and contains from 27 to 42% clay, and 22 to 35% sand. The basal contact of

the diamicton is planar and sharp. The diamicton is underlain by massive to horizontally bedded gravel, except in one occurrence (at Section 10) where the underlying unit is a clay-rich unit.

The pebble lithology of Type 1 Diamicton is variable, but is consistent within and sometimes between sections (Table 3.2). Section 1 has a pebble lithology represented by relatively equal percentages of carbonate and igneous and metamorphic rocks, and a slightly lower percentage of clastic rocks. Sections 2, 5, and 10 have a similar pebble lithology with relatively high percentages of carbonate rocks (43 to 58%). High percentages of igneous and metamorphic rocks (42 to 63%) occur at Sections 3 and 11.

Fabric analyses of pebbles generally show strong unimodal distributions parallel or near-parallel to ice-flow direction (145° azimuth as inferred from drumlins and grooves). Fabrics with S_1 values ranging from 0.48 to 0.76 (Figure 3.2) were determined at depths from 1.5 m to within 0.5 m of the base of the unit. Strong transverse, unimodal distributions (S_1 = 0.71) occur 6.0 m below the upper contact of the unit at the downstream part of Section 10 and the upstream part of Section 11. Two bimodal distributions show that one mode trends parallel to ice flow direction and a second mode trends north-south . These have low S_1 = 0.57 and 0.48. Plunges of all fabrics range from 0° to 16°. Several V_1 directions average approximately 336° azimuth, with a few oriented between 5° and 10°, 146° to 175°, and 31° to 43° azimuth.

Shard-like weathering occurs in the top 2 to 3 m of the unit in

Table 3.2 Pebble lithology results for Type 1 Diamicton

Sample #	Carbonate %	Metamorphic & Igneous %	Clastic %
Section #1			
P01	33	37	30
P02	43	37	20
P06	31	41	28
P44	48	34	18
Section #2			
P03	54	23	23
P04 (n=53)	58	21	21
P05	51	17	32
Section #3			
P07	32	47	21
P08	23	63	14
P09	24	56	20
P10	22	51(+1% volc)	26
P11	22	52	26
P12	30	42	28
P13	30	44	26
P14	28	45	27
Section #5			
P20	48	37	15
P21	43	40	17
Section #10			
P34	79	9	12
P35	74	10	16
P36	79	6	15
P37	79	8	13
P38	58	26	16
P39	70	17	13
P40	53	29	18
P41	69	13	18
P42	78	10	12
Section # 11			
P47	34	52	14

unimodal - parallel fabric patterns

unimodal - transverse fabric patterns

bimodal (parallel and transverse) fabric patterns

sample	V_1(trend)°	V_1(plunge)°	S_1(eigenvalue)	Section
F16	337	3.7	0.62	5
F35	146	6.1	0.72	10
F37	332	3.9	0.64	10
F01	031	8.2	0.71	11
F30	056	0.3	0.71	10
F03	043	12.0	0.52	2
F36	005	15.7	0.48	10

Figure 3.2 Fabric patterns of Type 1 Diamicton (N=50, K=100).

Sections 3, 5, and 10. No structures were observed in Sections 1, 2, and 11.

TYPE 1 DIAMICTON - INTERPRETATION

The sharp basal contact of Type 1 Diamicton suggests that subglacial deposition is more likely than supraglacial deposition. The diamicton is interpreted to be subglacial till, primarily on the bases of well ordered fabrics, absence of grading, and lack of sorted sediments. Pebble lithology results of Type 1 Diamicton suggest glacial ice sources from both eastern and western tributaries. Distribution of morainal deposits composed of till, t, and sandy till, ts, further indicates that a greater volume of glacial ice was received from western tributaries.

In Sections 3 and 5 the sharp basal contact forms a channel-like depression. The absence of lag deposits and channel scours at the basal contact suggest that the depression was probably not formed by meltwater flow. The depression probably was formed by the movement of an eroding debris rich glacier sole when the sliding velocity was greater than the basal melting rate (Hallet 1979). This suggests that the basal contact was formed subglacially by debris-rich basal ice, but it does not necessarily indicate that deposition must have occurred subglacially. However, it does suggest that basal deposition by meltout and/or lodgment is likely to have followed when the sliding velocity was reduced to or below the basal melting rate.

In Sections 1, 2, 10, and 11 the basal contact is sharp and

planar indicating that the glacier sole was active. There is no conclusive evidence as to whether deposition occurred subglacially or supraglacially based on the sharp basal contact.

Ordered fabrics are generally well preserved when little or no sediment reworking occurs. Several researchers (Elson 1961; Dreimanis 1976; Lawson 1977; Kruger 1979; Shaw 1982, 1983; Haldorsen and Shaw 1982) agree that these conditions are present when deposition occurs subglacially. Pebble orientations of subglacially derived tills are generally preserved parallel and transverse to ice-flow direction, resulting in both unimodal and bimodal distributions. Fabrics oriented transverse to ice-flow direction have been generally attributed to shear (Boulton 1971; Banham 1977; Shaw 1982; Rees 1983; Catto 1984). Several fabric analyses of Type 1 diamicton show strong unimodal distributions aligned parallel to ice-flow direction, whereas some fabrics show transverse orientations. A few bimodal distributions occur where orientations are both parallel and transverse to ice flow direction. The ordering of clast orientation in Type 1 Diamicton, therefore, suggests subglacial deposition.

The absence of grading in both the matrix and the clast content suggests that depositional processes were constant throughout the formation of Type 1 Diamicton. Supraglacial environments tend to be more dynamic with processes of resedimentation and winnowing by meltwater flow occurring sporadically, so that supraglacial tills would be expected to show a deposit with a high variability in texture (Dreimanis 1976). Therefore, the homogeneity of Type 1 Diamicton

suggests that it is less likely to have been deposited supraglacially. A debris flow deposit could form a deposit that was not graded, but it would be limited in its areal extent and thickness (Lawson 1979). Therefore, it is unlikely that a single debris flow could deposit a unit which was over 15 m thick, extended over almost 1 km, and occurred at several localities along the Finlay River.

The lack of grading in Type 1 Diamicton is probably the result of two factors: comminution and lithology. Debris in the basal zone of the glacier will undergo comminution leading to finer matrices (Haldorsen 1981). For this mechanism to produce an ungraded deposit, the debris must be continually entrained from the same lithologic unit. If a different lithology is introduced into the basal zone, then a different product will result. A breakdown through comminution can produce a different matrix texture, even though the same erosional processes occurred. This occurs as the result of lithologies having variable resistances to erosion by comminution (Dreimanis and Vagners 1972). Therefore, both the lithology and the depositional mechanism should remain relatively constant to produce a deposit that is not graded. These conditions are likely to persist in the subglacial environment.

Lack of sorted sediments associated with a structureless diamicton which contains unimodal pebble orientations suggest that the basal zone of glacier ice was debris-rich. In contrast, in conditions of debris-poor basal ice there is a greater chance that deposition of sorted sediments or a stratified diamicton reflecting bands of variable concentrations of debris may occur. Debris-poor ice would cause more

mixing to occur and result in increased scatter of pebble orientation (Lawson 1979). In debris-rich basal ice the amount of inter-clast spaces created from melting ice would be reduced and restrict mixing. Therefore, basal ice which contains significant concentrations of debris will produce a structureless deposit and unimodal pebble orientations typical of subglacial deposits.

The extensive drumlin field between Russel and Tsaydiz Creeks indicates that subglacial deposition was widespread (refer to discussion p.79). The occurrence and proximity of the drumlin field which shows similar orientation to pebble fabric orientations, strongly supports the argument for a subglacial environment of deposition.

The variability of pebble lithology is dependent on the geographic setting (Table 3.2). Sections 2, 5, and 10 are located adjacent to major eastern tributaries and have a pebble lithology which is consistently high in concentrations (43 to 58%) of mostly carbonate rocks. Hence, the pebble lithology suggests an eastern provenance. Sections 3 and 11 are located adjacent to western tributaries and have a pebble lithology of high concentrations (42 to 63%) of mostly igneous and metamorphic rocks suggesting a western provenance. Section 1 shows a pebble litholgy of undifferentiated provenance. Therefore, a pebble lithology indicating an eastern provenance occurs in locations adjacent to eastern tributaries, and a western provenance occurs in locations adjacent to western tributaries. A pebble lithology which is undifferentiated would most likely occur in locations where neither eastern or western sources are concentrated.

The distribution of morainal deposits composed of till, t, and sandy till, ts, suggests that more ice entered the Finlay River Valley from the western tributaries in comparison to eastern tributaries. Morainal deposits composed of sandy till, representing a discontinuous morainal cover, occur mostly in the northern and eastern side of the valley. Morainal deposits composed of till, representing a continuous morainal cover, occur mostly south of Mount Bennett and on the western side of the valley. Therefore, based on the assumption that the volume of morainal deposits is proportional to the amount of glacial ice, more ice entered the valley from the west in comparison to the east.

TYPE 1A DIAMICTON - DESCRIPTION

Isolated exposures in the central parts of Sections 5 and 8, which show fissility and well ordered fabrics are designated as Type 1A diamicton (Table 3.1). Map unit tsMp occurs at Section 5 and map unit tMp occurs at Section 8, thus indicating that Type 1A Diamicton is laterally discontinuous at the surface at Section 5 and laterally continuous at Section 8. The diamicton unit at both section locations has similar internal characteristics. Type 1A Diamicton is 5 to 8 m thick and consists of three zones: an upper, 2 to 4 m thick, brown zone; a middle, 1.5 to 2 m thick, mottled brown and grey zone; and a lower, 1 to 2 m thick, grey zone. The lower contact is covered.

Subrounded to subangular clasts range from 2 to 7 cm in diameter and form 30 to 40% of the unit. The diamicton matrix is similar to finer-grained samples of Type 1 Diamicton (Figure 3.3). It contains 25

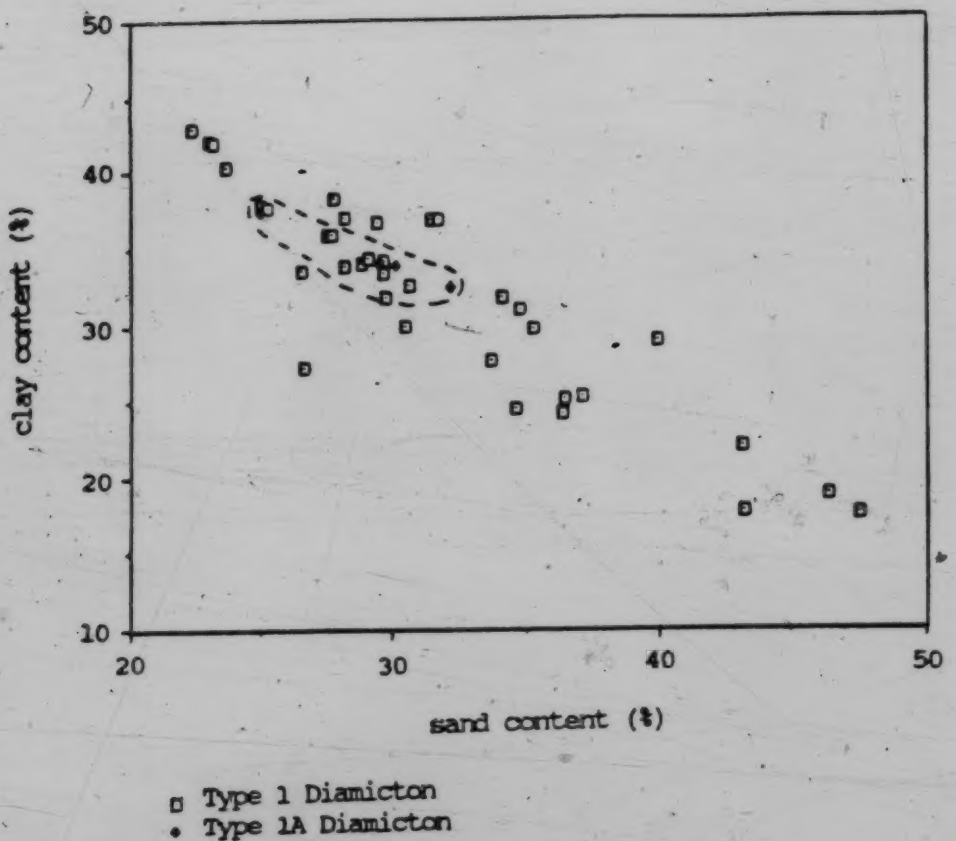


Figure 3.3 Grain size comparison of Types 1 and 1A Diamicton

to 32% sand and 32 to 37% clay. Samples from pebble assemblages from Section 5 and 8 contain 48 and 18% metamorphic and igneous clasts, 35 and 56% carbonate clasts, and 17 and 26% clastic fragments respectively.

Fabric analysis of oriented pebbles show very high S_1 values (0.84 to 0.73) trending nearly parallel to ice-flow direction as inferred from drumlins and grooves (Figure 3.4). Plunge inclinations are between 6 and 8° and V_1 directions are between 314° and 342° azimuth.

The fissility pattern in the central part of Section 5 consists of closely spaced (approximately 3 to 5 cm), horizontal and gently inclined fractures. This occurs in the lower 2 to 4 m of the unit (Plate 3.1), and is distinguishable from the overlying 1 to 2 m of shard-like weathering. In Section 8 a zone of well developed horizontal fissility 2 to 3 m thick occurs approximately 2 m below the upper contact of the unit (Plate 3.2). A few clasts, 4 to 5 cm in diameter, appear to be imbricated in the up-glacier direction with fine sand and silt laminae draping some clasts. Smaller clasts (1 to 3 cm in diameter) truncate fine sand and silt laminae.

TYPE 1A DIAMICTON - INTERPRETATION

Minor exposures of Type 1A Diamicton at Sections 5 and 8 can be interpreted as a subglacial till based on the same general characteristics of Type 1 Diamicton. Comparatively stronger pebble

sample: F18
Section: 5
V_1(trend): 322°
V_1(plunge): 8.8°
S_1(eigenvalue): 0.73

sample: F27
Section: 8
V_1(trend): 342°
V_1(plunge): 6.4°
S_1(eigenvalue): 0.84

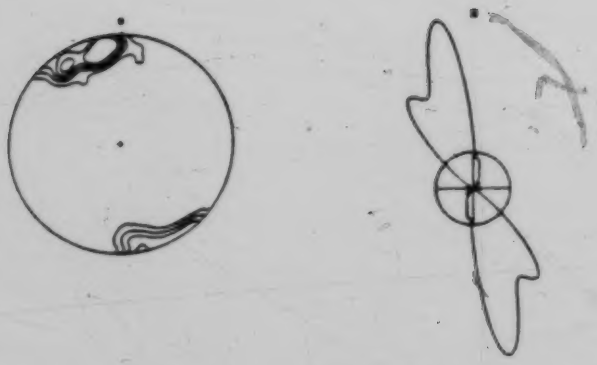


Figure 3.4 Fabric patterns of Type 1A Diamicton (N=50, K=100).

Plate 3.1 Fissility pattern of Type 1A Diamicton at Section 5

Plate 3.2 Fissility pattern of Type 1A Diamicton at Section 8

fabric orientations associated with well developed fissility suggest that Type 1A Diamicton can be further interpreted to be a lodgment till.

Evidence for lodgment in Section 8 is based on structural characteristics such as well developed horizontal fissility (Boulton 1975; 1976), imbricated clasts (Boulton 1975; 1976; Kruger 1979), fine sand and silt laminae draping clasts (Muller 1983), and truncation of fine sand and silt laminae by clasts (Muller 1983), in addition to strong fabric orientations.

The interpretation for lodgment in Section 5 is based on a well developed fissility associated with a strongly oriented pebble fabric (Boulton 1975). The argument from this interpretation is weak in comparison to the more diagnostic characteristics observed in Section 8. The fissility observed in Section 5 is probably the result of unloading due to increased vertical stresses caused by lodgment processes. The occurrence of a strongly oriented pebble fabric supports the argument for lodgment.

TYPE 1B DIAMICTON - DESCRIPTION

Coarse diamicton units containing sand and gravel lenses at or near the base of the unit are designated as Type 1B Diamicton (Table 3.1). They are exposed as the uppermost unit in the upstream and central parts of Section 5 and throughout Section 11.

Type 1B Diamicton occurs as map unit tsMp at Section 5 and as map unit tMp at Section 11. Therefore, Type 1B Diamicton is laterally

discontinuous at the surface at Section 5 and laterally continuous at Section 11. The internal characteristics of the diamicton at both section locations are similar. The thickness Type 1B Diamicton varies from 4 to 6 m thick and is olive-grey (5Y5/4 dry to 2.5Y3/2 wet). The basal contact is planar and sharp where marked by lenses at the base of the unit, and is otherwise irregular to wavy and gradational. The underlying unit is Type 1 Diamicton.

Subangular to subrounded clasts range from 2 to 7 cm in diameter and form 30 to 40% of the unit. The matrix contains 17 to 27% clay and 34 to 47% sand. The pebble lithology at Section 5 is represented by one sample of 56% clastic, 23% carbonate, 21% igneous and metamorphic rocks. A pebble lithology count was not completed on Type 1B Diamicton at Section 11.

Fabric measurements taken from approximately 1.5 m below the upper contact in Section 5 show strong fabrics parallel and near-parallel to ice-flow direction as inferred from drumlins and grooves (Figure 3.5). The V_1 directions are 314° and 167° azimuth, with plunge inclinations of 12° and 3° respectively. No fabric measurements were obtained from Section 11.

The diamicton is massive with moderately developed shard-like weathering in the upper 3 to 4 m of the unit. Sand and gravel lenses occur near the base of the unit. The lenses in Section 11 are plano-convex to biconvex, and are comparatively much larger than those observed in Section 5. The largest lens in Section 11 is approximately 200 m in length and 4 to 6 m thick. It is composed of horizontally

sample: F13
Section: 5
V_1(trend): 167°
V_1(plunge): 3.2°
S_1(eigenvalue): 0.67

sample: F15
Section: 5
V_1(trend): 314°
V_1(plunge): 12.6°
S_1(eigenvalue): 0.77

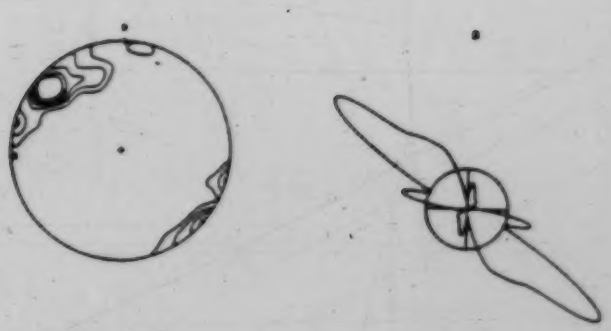


Figure 3.5 Fabric patterns of Type 1B Diamicton (N=50, K=100).

bedded, wavy to planar cross-bedded, and unbedded, fine to coarse sand and gravel (Plate 3.3). Thicknesses of individual strata vary and strata are laterally discontinuous. No grading of clast size was noted. The upper contact of the lens is gradational and irregular, while the lower contact is sharp and planar to slightly undulating. Two smaller sand and gravel lenses in Section 11 are approximately 30 to 50 m in length and 2 to 3 m thick. They are composed of similar grain sizes and structures as the large lens. One sand and gravel lens that occurs in the upstream part of Section 5 is approximately 1 m thick and 6 m in length, and truncated at one end by the cliff edge. It is generally plano-convex with a sharp, planar to slightly undulating basal contact and an upper irregular contact. It is composed of horizontally bedded gravel with minor interbeds of medium to coarse sand. No faulting was observed in the sediments contained in the lenses of Section 11 and the larger lens in Section 5. A small (approximately 70 cm in diameter), irregular shaped sand and gravel lens occurs approximately 1.5 m below the surface in the central part of Section 5 (Plate 3.4). It is composed of distorted fine to coarse sand and gravel.

TYPE 1B DIAMICTON - INTERPRETATION

Type 1B Diamicton is interpreted to be subglacial meltout till modified by post-depositional winnowing, based on the coarse matrix (compared to other diamicton types in the area), and associated plano-convex to biconvex sand and gravel lenses that occur at the base of the unit.

Plate 3.3 Large plano-convex sand and gravel lens at the base of Type 1B Diamicton at Section 11.

Plate 3.4 Deformed sand and gravel lens in Type 1B Diamicton at Section 5.

Type 1B Diamicton has a coarser matrix than the underlying Type 1 Diamicton. Type 1B Diamicton contains approximately 11 to 14% less clay, and 7 to 13% more sand than Type 1 Diamicton. These differences are not reflected in the large (2 to 7 cm in diameter) clast content, even though a higher clast content would be expected as the result of winnowing processes due to the loss of matrix sediments. In this case, the loss of fines from the matrix sediments does not result in changes probably because of the initial high clast content. Alternatively, the coarseness could be attributed to the entrainment of a coarser substrate. However, the local bedrock remains relatively constant and there is no geomorphic evidence to suggest that the surficial material was or is significantly coarser either up-valley or adjacent to the deposit. Hence, the coarseness of Type 1B Diamicton matrix is interpreted to be the product of a loss of the fine-grained fraction as the result of winnowing.

The coarseness of Type 1B Diamicton could be attributed to extraglacial debris (such as rockfall debris) which was subsequently transported and deposited supraglacially. If this were the case, the large clasts would show greater angularity in comparison to basally derived debris (Gardner 1978) such as the previously interpreted Type 1 Diamicton which directly underlies it. Since there are no differences in clast angularity between the underlying Type 1 Diamicton and Type 1B Diamicton it is unlikely that the debris of Type 1B Diamicton was supraglacially derived. In addition, the similarity in shapes of clasts between the two types suggests that they were probably derived from the

same subglacial source. Therefore, Type 1B Diamicton is interpreted to be subglacially deposited and subsequently modified by winnowing.

Large plano-convex to biconvex, sand and gravel lenses occur at or near the base of Type 1B Diamicton. The lenses probably represent wide, shallow subglacial channels formed by meltwater flow generally indicated by a plano-convex shape (Sudgen and John 1976). The shape of the channel is controlled by the erosion caused by the meltwater flow in the channel. Erosion occurred up into the ice rather than down into the substrate because the ice, which contains variable concentrations of debris, was less resistant than the underlying substrate (Nye 1972, Rothlisberger 1972). The type of erosion can vary depending on the amount of melting of the channel walls (Shreve 1972), which is related to the amount of basal debris. Where the ice is saturated with debris, melting of the channel walls is reduced significantly in comparison to areas where the ice is debris poor. Thus, slow melting will create a broad, shallow channel, whereas rapid melting will produce a deep, narrow channel. Therefore, the large lenses of Sections 5 and 11 were probably formed by slow melting of debris rich basal ice.

The plano-convex to biconvex shape of the lenses supports a subglacial environment of deposition. The irregular upper contact of the lenses indicates that ice bounded the upper surface of the channel where the sand and gravel sediments were deposited (Haldorsen and Shaw 1982). The subglacial environment most likely to preserve the shape of the lenses would be meltout as opposed to lodgment. Processes of lodgment would deform or destroy any evidence of the lens deposited by

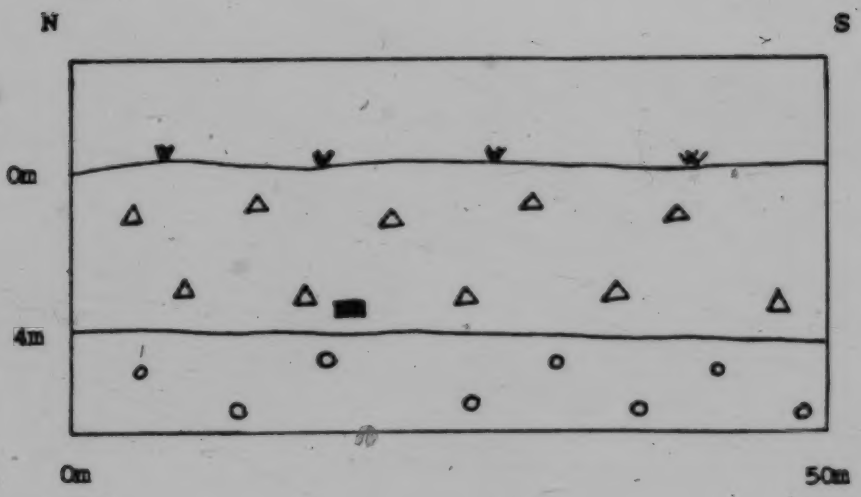
a subglacial channel (Shaw 1982). Deposition of subglacial debris by meltout can occur without disturbing the sand and gravel sediments previously deposited when the channel was filled with water.

The dimensions of the lenses and the horizontally bedded to massive sand and gravel sediments that form the lens suggest that they may represent a trunk valley channel (Schou 1949, Shreve 1972)). Trunk valley channels are likely to occur in large valley glaciers and indicate where the thalweg of the subglacial channel system occurred (Rothlisberger 1972, Walder and Hallet 1979). The other lenses occurring in Section 11 may represent minor lateral conduits.

TYPE 2 DIAMICTON - DESCRIPTION

Type 2 Diamicton (Table 3.1) occurs as the uppermost unit in Section 9 and is represented by diamicton beds interstratified with sand and gravel (Plate 3.5 and Figure 3.6). It occurs as map unit tsMp. The upstream part of Section 9 consists of one diamicton bed approximately 4 m thick. The central part of Section 9 consists of two diamicton beds separated by a sand and gravel unit. The lower diamicton bed is 50 to 80 cm thick. It extends approximately 50 to 70 m along the exposure and is directly overlain by a unit approximately 1 to 3 m thick, consisting of interbedded to interlaminated silt, sand, and gravel. The upper diamicton unit extends over 200 m and is approximately 1 to 2 m thick. The downstream part of Section 9 consists of three diamicton beds. The two upper diamicton beds are olive (5Y5/3 dry to 5Y4/3 wet), 2 to 5 m thick, and extend from 10 to 30 m. These

Plate 3.5 Composite of Type 2 Diamicton at a) upstream, b) center, and c) downstream parts of Section 9.



sample: F23
V_1(trend): 326°
V_1(plunge): 2.4°
S_1(eigenvalue): 0.85

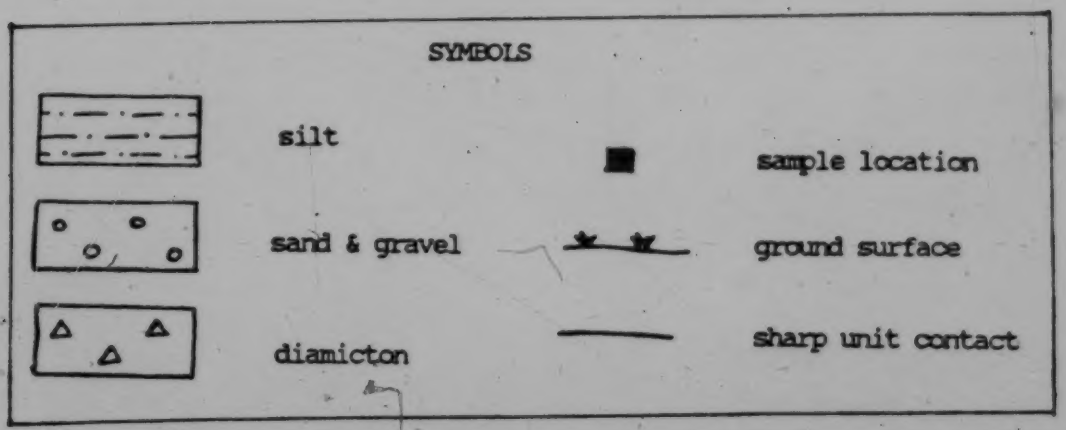
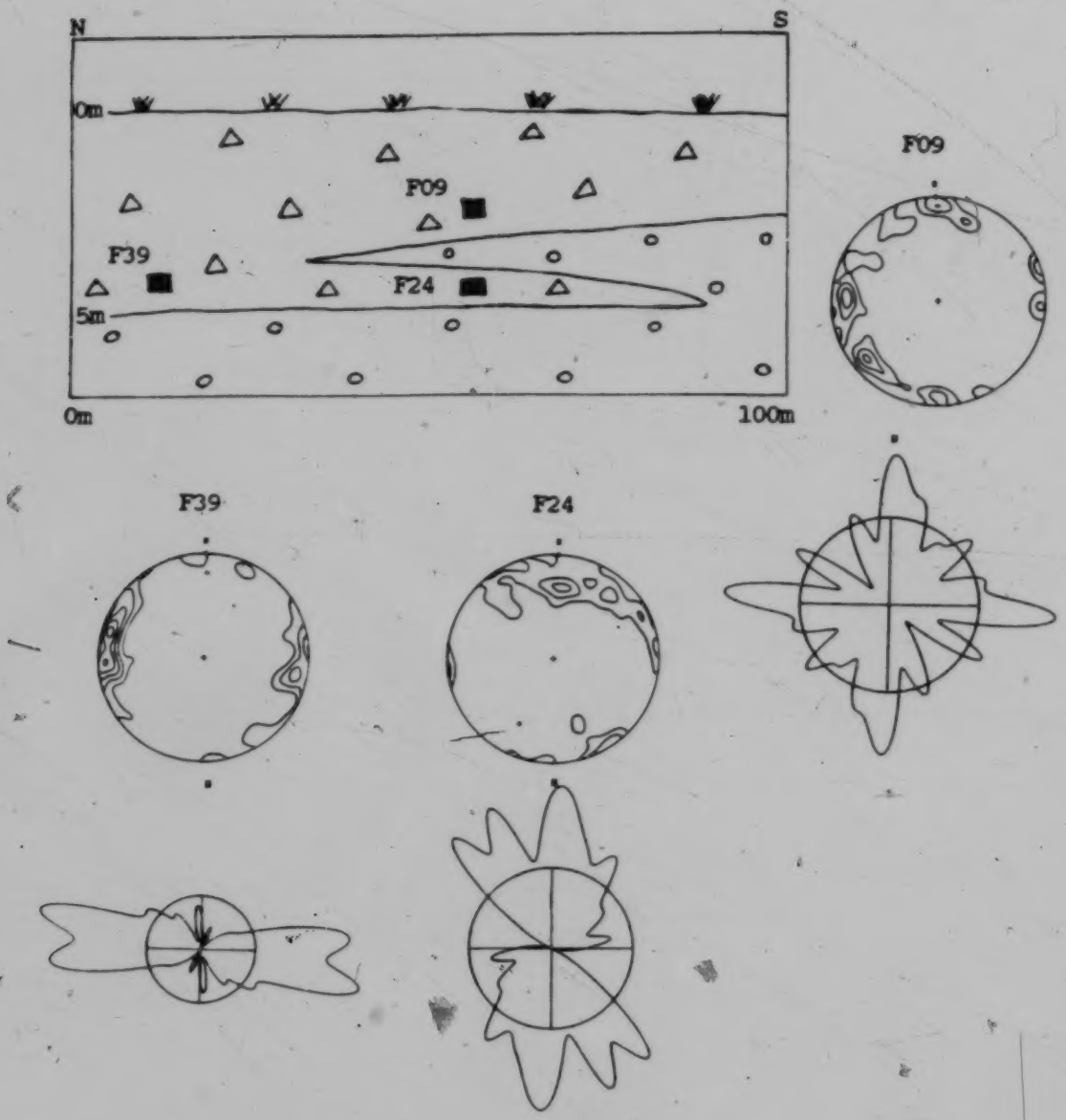
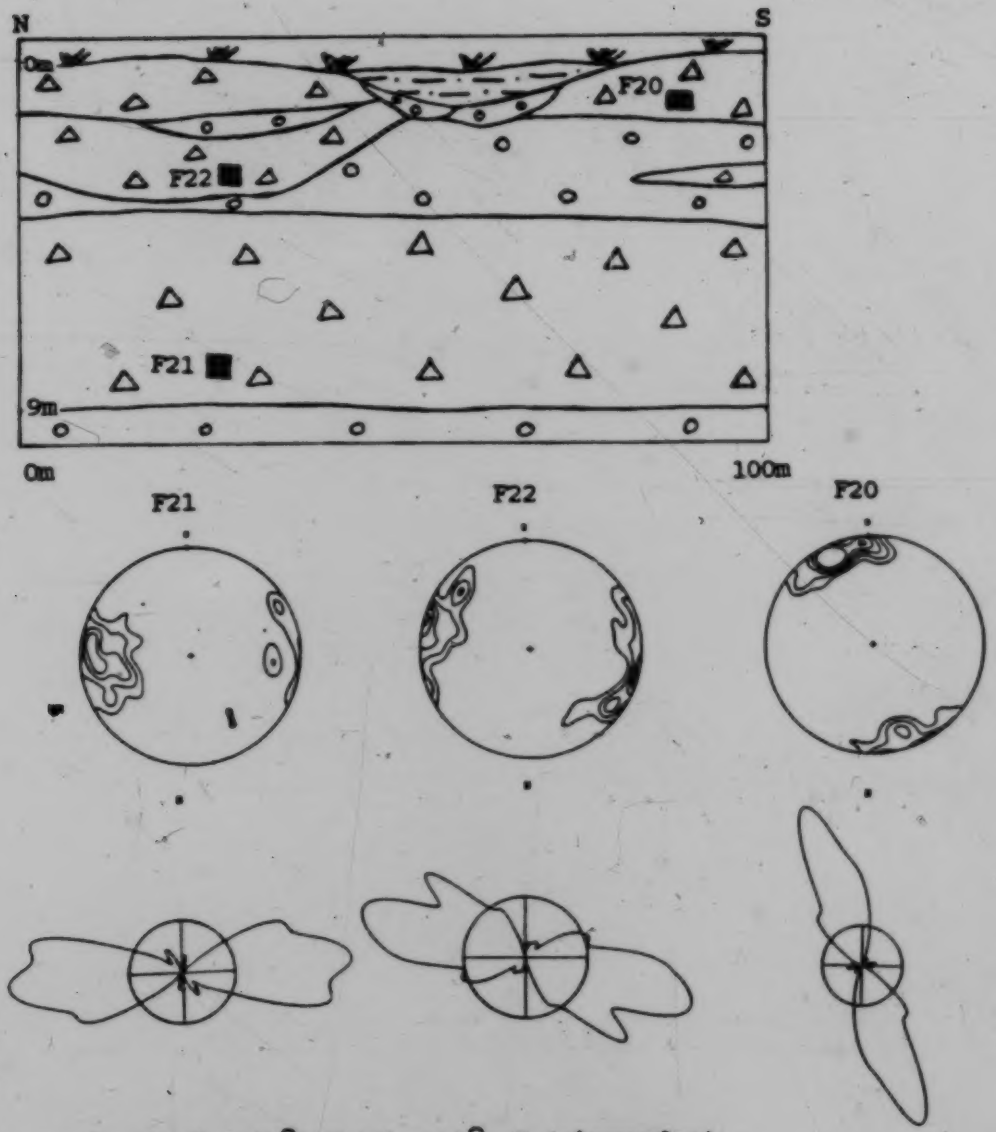


Figure 3.6a Location data of Type 2 Diamicton at upstream part of Section 9.



sample	V_1(trend)°	V_1(plunge)°	S_1(eigenvalue)
F09	237	8.7	0.48
F24	000	15.2	0.61
F39	280	2.9	0.73

Figure 3.6b Location data of Type 2 Diamicton at center part of Section 9.



sample	V_1(trend)°	V_1(plunge)°	S_1(eigenvalue)
F20	339	5.6	0.81
F21	269	5.3	0.75
F22	287	2.7	0.72

Figure 3.6c Location data of Type 2 Diamicton at downstream part of Section 9.

are interstratified with sand and gravel. The lowermost diamicton bed is approximately 6 m thick and extends approximately 400 m along the section. It is dark grey (5Y4/1 dry), with two olive (5Y5/3 dry) zones occurring in the upper and lower 10 to 50 cm of the unit. The upper and lower contacts of all diamicton beds are sharp and planar. The underlying unit consists of horizontally bedded to steeply dipping beds of sand and gravel.

The diamicton matrix of Type 2 Diamicton is generally coarser in texture than all other diamicton types (Figure 3.7). The matrix contains 12 to 24% clay and 29 to 56% sand. Subrounded to subangular clasts range from 1 to 5 cm in diameter and comprise 30 to 40% of the unit. In some of the diamicton beds the lower 20 to 30 cm of the unit has a lower percentage of large clasts (>5 cm). The diamicton contains 6 to 25% metamorphic and igneous clasts, 52 to 78% carbonate clasts, and 16 to 23% clastic fragments.

Fabric analysis was done on oriented pebbles were taken from several localities within Section 9. Fabrics parallel and transverse to ice-flow direction (as inferred from drumlins and grooves) with strong unimodal distributions of S_1 >0.60 occur in the upper diamicton beds from the upstream and downstream parts of the section. Plunge inclinations for unimodal fabrics vary from 2 to 15° with V_1 directions between 237° and 360° azimuth. One polymodal fabric (S_1 = 0.48) occurs at the central part of the section, in the lower diamicton bed.

The interstratified sand and gravels consist of massive to

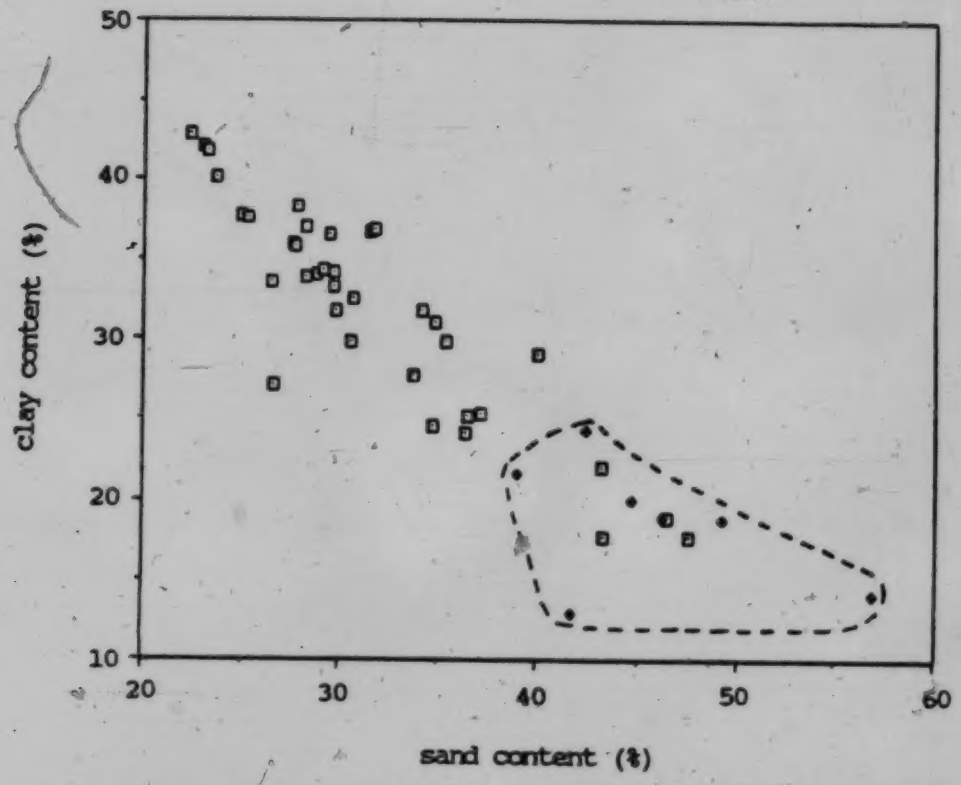


Figure 3.7 Grain size comparison of Types 1 and 2 Diamicton

horizontally interbedded to laminated silt, sand, and gravel. Stratification varies from less than 1 cm to 20 cm thick, averaging 10 to 15 cm thick, with most strata extending the length of the observed section. Large clasts are subrounded to subangular and average 2 to 7 cm in diameter. Discontinuous beds and lensoid to irregular shaped inclusions of diamicton occur within the sand and gravel strata.

TYPE 2 DIAMICTON - INTERPRETATION

Type 2 Diamicton is interpreted to represent debris flow deposits based on the sand and gravel sediments that are interstratified with the diamicton, locally variable fabric, and the geometry of the diamicton beds. In the downstream part of Section 9, Type 2 Diamicton can be interpreted in two ways based on its thickness and areal extent.

The pattern of sand and gravel sediments interstratified with diamicton beds supports deposition by debris flow. The areal extent (>1km) of sand and gravel sediments suggests that subglacial deposition was unlikely. In a subglacial environment deposition of the sand and gravel sediments would be restricted to an area controlled by the dimensions of the subglacial channel. The sand and gravel sediments have a tabular geometry and are as laterally extensive as the diamicton beds. There is no indication that the sand and gravel sediments were deposited in a confined area controlled by the shape of a subglacial channel. Therefore, deposition probably did not occur in a subglacial channel. Even if the channels were as extensive as the exposure of Type 2 Diamicton, the pattern of stratification would be represented by

laterally discontinuous layers. Hence, the laterally extensive and continuous sand and gravel sediments are more likely to have been deposited proglacially.

Distinction between subaerial and subaqueous debris flows is commonly determined by the nature of the diamicton. Large subaerial and subaqueous debris flows can deposit thick, massive diamicton (Middleton and Hampton 1976; Lawson 1982; Lowe 1982; Domack 1983) similar to Type 2 Diamicton. Subaerial debris flows have variable characteristics depending on the amount of water involved (Lawson 1982). The presence of characteristics such as thin silt laminations, loading and water escape structures, and graded bedding associated with subaqueous debris flows (Hampton 1972; Lowe 1982) distinguishes them from subaerial debris flows. Type 2 diamicton probably represents subaerial debris flow deposits because no subaqueous characteristics were observed.

Based on the interpretation that the sand and gravel sediments were deposited proglacially, the diamicton could have been deposited either by debris flows off a stable or retreating ice front, or subglacially by a fluctuating ice front. It is very unlikely that deposition occurred supraglacially since neither the surface morphology nor textural characteristics suggest this. The diamicton is more likely to have been the result of debris flows, based on the local variability of pebble fabric and the geometry of the diamicton beds. The fabrics of Type 2 Diamicton include polymodal, bimodal, and unimodal distributions. The strong unimodal fabrics may have developed as the result of reorientation due to mixing during flow (Boulton 1968). The

variability of fabric orientations of unimodal distributions present in Type 2 Diamicton may represent the variability of flow directions. The bimodal and polymodal fabrics are indications of debris flows with variable characteristics. Innes (1983) demonstated that different types of flows have different fabric patterns.

The geometry of the diamicton bed varies from discontinuous and lensoid, to continuous and thick (6 m). Where the diamicton is discontinuous and lensoid, the upper and lower contacts are sharp and the diamicton is often truncated by sand and gravel sediments. The diamicton units occur at different stratigraphic positions. This would eliminate the argument that the diamicton units represent the remnants of a unit eroded by sand and gravel sediments. Therefore, the variable stratigraphic position and discontinuous nature of both the diamicton and the sand and gravel sediments suggest that both were deposited simultaneously in the same depositional environment. Since it has already been established that the sand and gravel sediments were deposited proglacially, then the diamicton must as well have been deposited proglacially. One of the diamicton units is continuous and thick (6 m). Based on its geometry there is no conclusive evidence for either subglacial deposition or deposition by debris flow. It cannot be assumed that because the upper part of the exposure is proglacially deposited that the lower diamicton unit is as well. Therefore, the lower diamicton unit may have been deposited either subglacially or proglacially.

Based on the debris flow interpretation, Type 2 Diamicton

represents a geomorphological setting indicative of a former ice margin, similar to those documented by deJong and Rappol (1983), and Domack (1983). Thickness variations of multiple diamicton layers at the downstream end of Section 9 can be interpreted to represent two ice-marginal settings. The first possibility is that the ice-front was moving away from the site, simultaneously with the production of debris flows. Therefore, the first flow was initiated with the ice-front significantly closer to the site of deposition than subsequent flows. Another explanation would be that the ice-front is stable and produces a significantly large first debris flow and then subsequently minor flows; meaning that the first flow carried away most of the sediment available and that there was much less debris available for subsequent flows, resulting in deposition from minor flows. Both of these interpretations explain why the first debris flow, represented by the 6 m thick lowermost diamicton bed, is significantly thicker and more laterally extensive than the overlying thinner and discontinuous debris flow deposits which are interstratified with sand and gravel sediments. There is no evidence to support one setting over the other since deposition by debris flows from a stable or retreating ice front are equally possible. However, it can be concluded from the evidence given above that the ice front did not advance after the deposition by debris flow occurred.

B. INTERPRETATION OF SURFICIAL LANDFORMS

The surficial landforms of the Finlay River Valley are varied in origin and morphology. Some of the landforms include drumlins, grooves, hummocks, eskers, meltwater channels, gullies, and terraces. Most interpretations are based on information through airphoto analysis, in some cases supported by land reconnaissance.

DRUMLINS

Drumlins occur in morainal, M, dissected morainal, MD, undivided morainal and organic, MO, and morainal deposits overlying bedrock, M/B, map units. The most extensive drumlin field is located on the western side of the valley south of Russel Creek. This landform indicates that the base of glacier ice was active, with processes of erosion and deposition occurring. The internal characteristics of the drumlins were not investigated, therefore no attempt to interpret the processes involved in their formation is discussed (Menzies 1984). The drumlin field is typically located in the broadest part of the Finlay River Valley (Embleton and King 1975). In broad valleys of alpine environments the glacier is generally thought to be in a state of extending flow (Sudgen and John 1976), a condition favourable for the formation of drumlins (Shaw 1977).

GROOVES

Glacial grooves represented by grooved morainal deposits overlying bedrock, MU/B, and grooved bedrock, BU, map units are located

on the southern lee-side slope of the bedrock high directly south of Mount Bennett. They also suggest that the glacier was in a state of extending flow. In this case, extending flow resulted due to the movement of glacier ice down the slope (Nye 1959; Nye and Martin 1968). The bedrock, consisting predominantly of sandstone, shale, and conglomerate, was easily eroded by active basal ice and provided favourable conditions for the formation of glacial grooves.

HUMMOCKS

Hummocky topography represented by morainal stagnant-ice, MSI, map unit, is the result of supraglacial deposition. Debris can arrive at the supraglacial position either by englacial transport or by deposition from an extraglacial source (Boulton and Eyles 1979). Debris entrained subglacially may move to a higher englacial position when the glacier snout is in a state of compression, which can be induced by stagnation of glacier ice at the frontal margin (Boulton 1968). Exposure of englacial debris through ablation will provide a sediment source for supraglacial deposition.

Deposits from an extraglacial source are derived from valley sides and/or nunatak erosion. The volume of extraglacial debris is dependent on the area of the nunatak wall-rock exposed above the firn line, the proximity of the valley sides, ice velocity, and bedrock lithologies (Eyles 1979).

Debris derived from englacial and extraglacial sources show distinctive characteristics. Englacial debris characteristics are

closely associated with subglacial debris characteristics. In contrast, extraglacial debris is coarse, granular, poorly sorted, and lacks fines (Eyles 1979). In addition, the clasts may be oxidized, angular, lack striations, and have no preferred orientation. Interpretation of the origin of the sediments that make up the hummocky topography is not discussed since the sediments were not exposed in vertical section. It can be concluded, however, that this topography probably represents a frontal margin where ice stagnation occurred, thereby resulting in conditions that were favourable for accumulation of debris from both englacial and extraglacial sources.

ESKERS

Eskers are commonly associated with glaciofluvial ice-contact, GIC, and undivided morainal and glaciofluvial ice-contact, MGIC, map units, and occur less frequently with morainal stagnant-ice, MSI, and dissected morainal stagnant-ice, MSID, map units. Deposition and preservation of eskers are most likely to occur beneath thin or stagnant ice (Sudgen and John 1976) and generally indicate the last ice-flow direction near the glacier front. An exception to this is the MGIC map unit, where an esker is oriented transverse to ice-flow direction and occurs on a valley side. The orientation of this esker is controlled by topography and indicates where a lateral drainage channel was situated.

MELTWATER CHANNELS

Meltwater channels were initially almost always interpreted, particularly in Britain, to be channels that were cut by the overflow of lakes dammed by glaciers (Kendall 1902, and Charlesworth 1955). This was the only mechanism thought to explain the large volume of meltwater required to fill the dimensions of the channels produced. Later on, in Scandinavia, Sissons (1958) argued in favour of a subglacial origin. Development of the theory for meltwater flow within a glacier (Shreve 1972, and Nye 1973) has since helped to support the subglacial interpretations, with the added understanding of the processes involved. At present, the origin of most meltwater channels is generally believed to be either subglacial or marginal to sub-marginal (Sudgen and John 1976).

The morphology of most meltwater channels in the Finlay River Valley suggests that they were formed in contact with, either under or adjacent to, glacial ice and not subaerially in the ice-proximal area of the glacier. The flat bottoms and steep sides represent the full dimension of a former channel whose lower parts flowed with meltwater and remainder was occupied by ice. This would significantly reduce the amount of meltwater that was previously thought to be required since the channel can be eroded partly by meltwater flow and partly by glacial ice. It would be difficult for active slope processes of a channel to have formed such channels subaerially. Therefore, it is unlikely that channels of the Finlay River Valley were formed proglacially.

On the eastern margin of the map area, south of Paul River, meltwater from tributary glaciers was blocked by ice occupying the Finlay River Valley and formed ice-dammed lakes in the tributaries (Mathews 1980). This probably occurred as the result of tributary glaciers retreating more rapidly than the main valley ice. Subsequently, the main valley ice retreated and allowed the ice-dammed lakes to drain. The catostrophic drainage of meltwater probably occurred along the lateral margin and under the flanks of the main valley ice suggesting that the channels were formed marginally to submarginally. In comparison to other meltwater channels of the map area, the large dimensions of these channels suggest that a significantly greater amount of meltwater flow was involved in their formation.

On the western side of the valley meltwater channels are narrow, of varying extent, and oriented both parallel and transverse to ice-flow direction. The channels parallel to ice-flow direction are extensive (approximately 10 to 20 km in length) and occur alongside the wall of prominent bedrock highs, indicating that they probably formed along the lateral margin of the glacier. Meltwater channels that are presently occupied by Tsaydiz and McGraw Creeks could have originated either subglacially or at the frontal margin of the glacier. Based on their transverse orientation it is more likely that they formed along the margin of the ice-front. This would suggest that the glacier was stable at the positions of these creeks during the final retreat. Most of the smaller meltwater channels are also oriented transverse to

ice-flow direction, indicating ice-front positions that were comparatively short lived.

It is difficult to be certain of the origin of the meltwater channels of the Finlay River Valley without a vigorous examination of them. Even so, meltwater channels could be initiated subglacially, or be re-established from ones formed in a previous glacial event, during ice advance, and then later exploited in a marginal or submarginal position during the retreat phase (Sudgen and John 1976). For these reasons their origin is merely speculation.

MINOR MELTWATER CHANNELS

Minor meltwater channels occur predominantly with the dissected morainal, MD, map unit with most located on the western side of the valley south of Stelkuz Lake. The minor meltwater channels occur adjacent to meltwater channels and along valley sides. Based on their close association with meltwater channels it is assumed that most minor meltwater channels were also formed in contact with glacier ice and at about the same time as the formation of meltwater channels. Their widespread distribution suggests that they were formed both subglacially and marginally or sub-marginally.

TERRACES

Terraces are commonly constructed or carved as the result of base level changes. Changes in base level can occur as the result of eustatic, isostatic, tectonic, or climatic changes. Due to the great

geographic distance from the sea, changes in sea level are not likely to affect the base level of the Finlay River Valley. It is unlikely that the terraces are related to deglaciation, due to their young age (refer to discussion in Chapter 4), suggesting that the terraces are not the result of isostatic rebound. The last important tectonic movement along the Northern Rocky Mountain Trench was in Late Cretaceous to Paleocene (Leech 1966), with some minor deformation following the Early Oligocene (Hopkins et al 1972). Hence, tectonic processes were most likely not involved.

Climatic changes have been suggested during the Late Wisconsinan to Early Holocene (c 10,000 to 4,000 yr BP) through palaeoenvironmental studies (Kearney and Luckman 1981; 1983) in the central Rocky Mountains of British Columbia and Alberta. Therefore, it is most likely that the terraces of the Finlay River Valley were formed in response to climatic changes conducive to terrace development.

To explain the processes necessary for terrace formation, it must be determined whether the terrace is erosional, depositional, or a combination of both. Observations of the two lower terraces (t_1 = 4 to 6 m level and t_2 = 8 to 10 m level) indicate that they are erosional terraces. The highest terrace (t_3 = 12 m level) can be interpreted as either erosional or depositional since there is no reference point or lateral continuity to compare this terrace with older deposits of the valley floor. The high terrace may be partly depositional due to the presence of a gravel lag deposit which occurs approximately 4 to 7 m below the terrace surface level. The fact that

there is no significant accumulation of a capping unit, t_3 is probably more likely to be a constructional terrace.

C. SUMMARY INTERPRETATIONS OF DIAMICTON TYPES AND LANDFORMS

Interpretations suggest that most deposits and landforms of the Finlay River Valley are the result of glacial debris being transported and deposited subglacially. Evidence for this includes: a) presence of ice-directional features such as drumlins and grooves; b) morainal deposits represented predominantly by subglacial tills; and c) lack of supraglacial deposits and landforms in the Finlay River Valley. Distribution of morainal deposits indicates that less ice flowed into the valley from eastern tributaries than from western tributaries. An isolated area which lies adjacent to the Finlay River Valley is a valley marginal channel located on the western edge of the map area between McGraw and Tsaydiz Creeks. This is the only area where supraglacial deposition occurred.

As discussed previously, landforms such as drumlins and grooves indicate active basal ice conditions and suggest that the basal zone of the glacier was debris-rich. The orientation of these landforms is evidence for a major lobe of ice which flowed through the Stelkuz Creek Valley. This represents the path through which glacial debris from western sources entered the Finlay River Valley.

Types 1, 1A, and 1B Diamicton represent subglacial tills. Eventhough Type 2 Diamicton was deposited by debris flows, there is evidence that the debris originated mostly from the englacial and subglacial zones and was not supraglacial debris. This evidence suggests that most of the glacial debris was carried in the englacial and basal zones of the glacier in the Finlay River Valley.

The lack of supraglacial deposits and landforms in the Finlay River Valley also suggest that the amount of debris in the supraglacial position was insignificant. This would suggest that a) there was very little nunatak high-angled wall-rock exposed adjacent to the glacier, and b) the glacier was predominantly in a state of extending flow.

The distribution of morainal deposits represented by till, t, and sandy till, ts, compositions reflects the amount of glacier ice which flowed in from the eastern and western tributaries. The morainal deposits composed of till occur mostly on the western side of the valley south of Mount Bennett. The morainal deposits composed of sandy till, which indicate that the morainal deposits are discontinuously exposed on the surface, occur mostly on the eastern side of the valley. This distribution indicates that a much greater volume of ice was received from western tributaries in comparison to eastern tributaries. Evidence that ice flowed into the Finlay River Valley from eastern and western tributaries is demonstrated in pebble lithology results. An eastern lithology is reflected in samples located adjacent to eastern tributaries, which have proportionally higher concentrations of carbonate rocks. Proportionally higher concentrations of igneous and metamorphic rocks in samples located adjacent to western tributaries indicate a western lithology.

The explanation for supraglacial deposition occurring in the valley marginal channel is based on two factors: a) the geographic setting; and b) the amount of nunatak wall-rock exposed adjacent to the glacier. During the retreat phase, ice in the valley marginal channel

was separated from the main valley ice of the Finlay River Valley. This allowed for the valley marginal ice to act independently from the main valley ice. When compressional flow occurred at the ice front with the additional factor that supraglacial debris accumulated from the exposed nunatak wall-rock adjacent to the glacier, ice stagnation to occur. This resulted in the deposition of hummocky topography, esker formation, and glaciofluvial ice-contact deposition.

CHAPTER 4

GLACIAL HISTORY AND CHRONOLOGY OF THE FINLAY RIVER VALLEY

The glacial deposits and landforms in the Finlay River Valley are the result of the Late Portage Mountain Advance (after Rutter 1977a). The glacial ice was topographically controlled with an upper depositional ice limit at approximately 1500 m a.s.l. Pebble lithology results of clasts from morainal deposits suggest that glacier ice joined with the main valley from the eastern and western tributaries. The distribution of morainal deposits also suggests that more glacial ice was received from the west in comparison to the east.

The morainal deposits and landforms in the southern part of the map area were mostly subglacially transported and deposited. This is indicated by drumlins, grooves, an extensive morainal subglacial till, and lack of supraglacial deposits and landforms. The valley marginal channel, which lies adjacent to the Finlay River Valley, is the only part of the map area where supraglacial deposition occurred.

Deglaciation of the main valley appears to have been continuous. There is no evidence of glacial standstills marked by end moraines or extensive glaciofluvial ice-contact deposits. The large meltwater channels on the eastern side of the valley were formed when the ice-dammed lakes in the tributaries were breached. The smaller and more extensive meltwater channels on the western side of the valley were formed both subglacially and marginally to submarginally. Deglaciation of the valley marginal channel is marked by narrow meltwater channels and gullies, and eskers which developed adjacent to stagnant ice

blocks

Three terrace levels occur along the Finlay River. The upper, approximately 12 m terrace cannot be interpreted preferentially as constructional versus erosional. The two lower terraces (t_1 at 4-6 m and t_2 at 8-10 m) are erosional. Charcoal samples taken from overbank silt deposits of these terraces date them between 3440 +/- 60 (GSC 4082) and 5780 +/- 110 (Alta Envir 391C) years BP (Table 4.1), indicating that their formation was not related to deglaciation of the Finlay River Valley. Thus, they are most likely the result of construction and erosion by fluvial processes in response to base level changes acting under a climatic regime similar to that of the present.

A thick vegetational cover had been established prior to approximately 700 years BP. Dates of insitu charcoal samples of 510 +/- 40 (GSC 4080) and 660 +/- 90 (Alta Envir 393C) years BP represent a major forest fire.

TABLE 4.1 **Radiocarbon results of charcoal samples from the two lower terraces.**

SAMPLE NO.	LOCATION	TERRACE LEVEL	LABORATORY	DATE (years BP)
T92	57° 08' 30" N 125° 14' 38" W	8-10 m	Alta Envir 391C	5780 +/- 110
*T96	57° 09' 15" N 125° 16' 30" W	8-10 m	GSC 4109	4090 +/- 90
T98	57° 09' 26" N 125° 17' 03" W	4-6 m	Alta Envir 392C	4830 +/- 150
*T94	57° 14' 26" N 125° 24' 17" W	4-6 m	GSC 4082	3440 +/- 60

*samples identified by R.J. Mott as Picea sp. (G.S.C. Wood Identification Reports 85-26 and 85-28)

"**Alta Envir**" Alberta Environmental Centre, Environmental Isotope Section, Vegreville, Alberta

"**GSC**" Geological Survey of Canada Radiocarbon Laboratory, Ottawa, Ontario

BIBLIOGRAPHY

American Society for Testing Materials, 1964. Standard method for grain size analysis of soils, ASTM D422-63. In Procedures for Testing Soils. ASTM, Philadelphia, pp. 11-25

American Society for Testing Materials, 1964. Standard method for hydrometer analysis of soils, ASTM D423- 63, In Procedures for Testing Soils. ASTM, Philadelphia, pp. 95-106

Banham, P.H. 1977. Glaciotectonites in till stratigraphy. Boreas 6, pp. 101-105

Bobrowsky, P.T., Levson, V., Liverman, D.G.E., and Rutter, N.W. 1987. Quaternary Geology of Northwestern Alberta and Northeastern British Columbia. XIIth INQUA Congress Field Excursion A-24 Guidebook, 62 pp.

Boulton, G.S. 1968. Flow tills and related deposits on some Vestspitzbergen glaciers. Journal of Glaciology 7, pp. 391-412

Boulton, G.S. 1971. Till genesis and fabric in Svalbard, Spitzbergen. In R.P. Goldthwait (ed) Till: a Symposium. Ohio State University Press, Columbus, Ohio, pp. 41-72

Boulton, G.S. 1975. Processes and patterns of subglacial sedimentation: a theoretical approach. In H.E. Wright and J.T. Mosley (eds) Ice Ages:

Ancient and Modern. Seel House Press, Liverpool, pp. 7-43

Boulton, G.S. 1976. The development of geotechnical properties in glacial tills. In R.F. Legget (ed) Glacial Till. Royal Society of Canada Special Publication 12, LeDroit Commercial Printers, Ottawa, pp. 292-304

Boulton, G.S. and Eyles, N. 1979. Sedimentation by valley glaciers; a model and genetic classification. In Ch. Schluchter (ed) Moraines and Varves, A.A. Balkema, Rotterdam, pp. 11-23

Canada Soil Survey Committee, Subcommittee on Soil Classification 1978. The Canadian System of Soil Classification. Canadian Department of Agriculture Publication 1646, Supply and Services Canada, Ottawa, Ontario, 164 pp.

Catto, N.R. 1984. Glacigenic deposits at the Edmonton Convention Centre, Edmonton, Alberta. Canadian Journal of Earth Sciences 21, pp. 1473-1482

Charlesworth, H.A.K., Cruden, D., Ramsden, J., and Huang, Q. 1987. A FORTRAN-77 program for processing orientation data on a microcomputer. in press 15 pp.

Charlesworth, J.K. 1955. Late glacial history of the highlands and islands of Scotland. Transactions Royal Society of Edinburgh 62, pp.

769-928

Cheeney, R.F. (ed) 1983.Statical methods in geology. George Allen Unwin Publishers Ltd, London. 169 pp.

Compton, R.R. (ed) 1962. Manual of Field Geology. Wiley, New York

Dawson, G.M. 1888. Recent observations on the glaciation of British Columbia and adjacent regions. American Geologist 3, pp. 249-253

Domack, E.W. 1983. Facies of Late Pleistocene glacial-marine sediments on Whidbey Island, Washington: an isostatic glacial-marine sequence. In B.F. Molnia (ed) Glacial-marine sedimentation. Plenum Press, New York, pp. 535-570

Dreimanis, A. 1976. Tills, their origin and properties. In R.F. Legget (ed) Glacial till; an interdisciplinary study. Royal Society of Canada Special Publication 12, Ottawa, pp. 11-50

Dreimanis, A. and Vagners, U. 1971. Bimodal distribution of rock and mineral fabrics in basal till. In R.P. Goldthwait (ed) Till: a Symposium. Ohio State University Press, Ohio, pp. 237-250

Elson, J.A. 1961. The geology of tills. In E. Penner and J. Butler (eds) Proceedings of 14th Canadian Soil Mechanics Conference. National

Research Council of Canada, Commission on Soil and Snow Mechanics Technology, Memorandum 69, pp. 5-36

Embleton,C. and King, C.A.M. (eds) 1975. Glacial Geomorphology. Edward Arnold, London, 573 pp.

Environment Canada 1982. Canadian Climate Normals 1951-1980, Temperature and Precipitation, British Columbia. Ottawa, Canada, 268 pp.

Eyles, N. 1979. Facies of supraglacial sedimentation on Icelandic and Alpine temperate glaciers. Canadian Journal of Earth Sciences 16, pp. 1341-1362

Eyres, F.H. (ed) 1980. Forest Cover Types of the United States and Canada. Society of American Foresters, Washington, unpaginated

Folk, R.L. (ed) 1980. Petrology of Sedimentary Rocks. Hempill Publishing Company, Austin, Texas. 184 pp.

Gabrielse, H. n.d. Geology of Toodoggne (NTS 94E) and Ware (NTS 94W/2) Map Areas. Geological Survey of Canada Open File 483

Gardner, J. 1978. Wenkchemna Glacier: ablation complex and rock glacier in the Canadian Rocky Mountains. Canadian Journal of Earth Sciences,

15, pp. 1200-1204

Haldorsen, S. 1981. The grain size distribution of subglacial till and its relation to glacial crushing and abrasion. Boreas 10, pp. 91-105

Haldorsen, S. and Shaw, J. 1982. The problem of recognizing melt-out till. Boreas 11, pp. 261-277

Hallet, B. 1979. A theoretical model of glacial abrasion. Journal of Glaciology 23, pp. 39-51

Hampton, M. 1972. The role of subaqueous debris flow in generating turbidity currents. Journal of Sedimentary Petrology 42, pp. 775-793

Holland, S.S. 1972. Landforms of British Columbia, A Physiographic Outline. British Columbia Department of Mines and Petroleum Resources, Bulletin 48, Victoria, 138 pp.

Hopkins, W.S., Rutter, N.W., and Rouse, G.E. 1972. Geology, paleoecology, and palynology of some Oligocene rocks in the Rocky Mountain Trench of British Columbia. Canadian Journal of Earth Sciences 9, pp. 460-470

Innes, J.L. 1983. Debris Flows. Progress in Physical Geography, pp. 469-501

deJong, M.G.G. and Rappol, M. 1983. Ice-marginal debris flow deposits in western Allgau, southern West Germany. Boreas 12, pp. 57-70

Kearney, M.S. and Luckman, B.H. 1981. Evidence for late Wisconsin - early Holocene climatic/vegetation change in Jasper National Park, Alberta. In W.C. Mahaney (ed) Quaternary Paleoclimates. Dowden, Hutchinson and Ross, Stroudsburg, Pennsylvania. pp. 85-105

Kearney, M.S. and Luckman, B.H. 1983 Postglacial vegetational history of Tonquin Pass, British Columbia. Canadian Journal of Earth Sciences 20, pp. 776-786

Kendall, P.F. 1902. A system of glacier-lakes in the Cleveland Hills. Quarterly Journal of Geological Society of London 58, pp. 471-571

Kruger, J. 1979. Structures and textures in till indicating subglacial deposition. Boreas 8, pp. 323-340

Lawson, D.E. 1977. Sedimentation in the terminus of the Matanuska Glacier, Alaska. Ph D Thesis, Department of Geology, University of Illinois, Urbana, Illinois

Lawson, D.E. 1979. A sedimentological analysis of the western terminus of the Matanuska Glacier, Alaska. United States Army Cold Regions

Research and Engineering Laboratory. Report 79-9, 122 pp.

Lawson, D.E. 1982. Mobilization, movement, and deposition of active subaerial sediment flows, Matanuska Glacier, Alaska. Journal of Geology 90, pp. 279-300

Leech, G.B. 1966. The Rocky Mountain Trench. Royal Society of Canada Transactions 20, pp. 17-31

Lowe, D.R. 1982. Sediment gravity flows II: Depositional models with special reference to the deposits of high-density turbidity currents. Journal of Sedimentary Petrology 52, pp. 279-297

Mark, D.M. 1971. Rotational vector procedure for analysis of till fabrics. Geological Society of America Bulletin 82, pp. 2661-2666

Mark, D.M. 1973. Analysis of axial orientation data, including till fabrics. Geological Society of America Bulletin 84, pp. 1369-1374

Mark, D.M. 1974. On the interpretation of till fabrics. Geology 2, pp. 101-104

Mathews, W.H. 1980. Retreat of the last ice sheet in north-eastern British Columbia and adjacent Alberta. Geological Survey of Canada Bulletin 331, Ottawa, 22 pp.

McConnell, R.G. 1896. Report on an exploration of the Finlay and Omineca Rivers. Geological Survey of Canada Annual Report (New Series) 7, 1894, pp. 6C-40C

Menzies, J. 1984. Drumlins: a Bibliography. XVII Geo Books, Norwich, 117 pp.

Middleton, G.V. and Hampton, M.A. 1976. Subaqueous sediment transport and deposition by sediment gravity flows. In D.J. Stanley and D.J.P. Swift (eds) Marine sediment transport and environmental management. Wiley, New York, pp. 197-220

Ministry of Forest, British Columbia 1984. Forest and Range Resources Analysis, 1984. Ministry of Forests' Strategic Studies Branch, British Columbia, 282 pp.

Muller, E.H. 1983. Dewatering during lodgment of till. In E.B. Evenson, Ch. Schlutcher, and J. Rabassa (eds) Till and Related Deposits. Balkema Press, Rotterdam, pp. 13-18

Nye, J.F. 1959. The deformation of a glacier below an ice fall. Journal of Glaciology 3, pp. 387-408

Nye, J.F. 1973. Water at the base of a glacier. International

Association of Scientific Hydrology Publication 95 (Symposium on the Hydrology of Glaciers, Cambridge, 9-13 September, 1969), pp.189-194

Nye, J.F. and Martin, P.C.S. 1968. Glacial erosion. International Association of Scientific Hydrology Publication 79, pp. 78-86

Powers, M.C. 1953. A new roundness scale for sedimentary particles. Journal of Sedimentary Petrology 23, pp. 117-119

Prest, V.K. 1969. Retreat of Wisconsin and Recent ice in North America. Geological Survey of Canada Map 1257A, scale 1:5,000,000.

Rees, A.I. 1983. Experiments on the production of transverse grain alignment in a sheared dispersion. Sedimentology 30, pp. 437-448

Rothlisberger, H. 1972. Water pressure in intra- and subglacial channels. Journal of Glaciology 11, pp. 177-204

Rowe, J.S. 1972. Forest Regions of Canada. Canadian Forest Service Publication 1300, Department of the Environment, Ottawa. 172 pp.

Rutter, N.W. 1977a. Multiple glaciation in the area of Williston Lake, British Columbia. Geological Survey of Canada Bulletin 273, 31 pp.

Rutter, N.W. 1977b. Methods of terrain evaluation, Mackenzie

transportation corridor, NWT, Canada. Earth Surface Processes 2, pp. 295-308

Rutter, N.W. and Taylor, G.C. 1968. Bedrock geology along the Ingenika and Finlay Rivers, Peace River Reservoir area, British Columbia. Geological Survey of Canada Paper 68-10. 9 pp.

Ryder, J. 1971. The stratification and morphology of para-glacial alluvial fans in south-central British Columbia. Canadian Journal of Earth Sciences 8, pp. 279-298

Schou, A. 1949. The landscapes. In N. Nielsen (ed) Atlas of Denmark. Copenhagen, Denmark

Shaw, J. 1977. Till body morphology and structure related to glacier flow. Boreas 6, pp. 189-201

Shaw, J. 1982. Meltout till in the Edmonton area, Alberta, Canada. Canadian Journal of Earth Sciences 19, pp. 1548-1569

Shaw, J. 1983. Forms associated with boulders in melt-out till. In E.B. Evenson, Ch. Schlutcher, and J. Rabassa (eds) Tills and Related Deposits. Balkema Press, Rotterdam, pp. 3-13

Shreve, J. 1972. Movement of water in glaciers. Journal of Glaciology

11, pp. 205-214

Sissons, J.B. 1958. Supposed ice-dammed lakes in Britain, with particular reference to the Eddelston valley, southern Scotland. Geografiska Annular 40, pp. 159-187

Sudgen, D.E. and John, B.S. 1976. Glaciers and Landscapes, a Geomorphological Approach. Edward Arnold, London, 376 pp.

Tipper, H.W., Woodsworth, G.J., and Gabrielse, H. 1981. Assemblage Map of Canadian Cordillera and Adjacent Parts of the United States of America. Geological Survey of Canada Map 1505A, scale 1:2,000,000

Walder, J. and Hallet, B. 1979. Geometry of former subglacial water channels and cavities. Journal of Glaciology 23, pp. 335-346

Appendix I Pebble fabric analysis

SAMPLE #	TREND (°)			PLUNGE (°)			EIGENVALUE/N		
	V_1	V_2	V_3	V_1	V_2	V_3	S_1	S_2	S_3
Section #1									
F40	5.6	274.4	163.2	12.8	5.1	76.2	.7303	.1909	.0788
Section #2									
F03	42.9	312.7	217.1	11.9	1.2	78.0	.5151	.4039	.0810
F04	10.7	280.1	153.6	6.8	5.1	81.5	.5820	.3338	.0842
Section #3									
F07	324.4	55.0	226.4	2.2	15.1	74.7	.5389	.3052	.1559
F10	329.8	239.3	123.8	7.6	3.7	81.6	.7149	.1462	.1389
Section #5									
F13	167.2	75.3	262.7	3.2	30.5	59.3	.6673	.2074	.1253
F15	314.3	45.7	161.6	12.6	6.2	75.9	.7679	.1800	.0521
F16	337.2	71.4	244.0	3.7	48.3	41.5	.6185	.2657	.1158
F17	174.6	84.0	328.2	8.8	4.3	80.2	.5953	.2532	.1515
F18	322.0	53.5	190.9	8.8	9.8	76.7	.7336	.1654	.1010
Section #8									
F27	341.7	251.0	118.0	6.4	6.1	81.1	.8378	.1012	.0610
Section #9									
F09	237.2	328.5	101.8	8.7	8.4	77.8	.4849	.4326	.0825
F20	339.4	249.3	150.2	5.6	0.9	84.3	.8095	.1275	.0630
F21	269.4	147.8	5.3	14.6	63.5	21.6	.7463	.1302	.1235
F22	287.2	197.1	69.8	2.7	2.1	86.6	.7242	.1842	.0915
F23	325.6	235.4	80.5	2.4	5.1	84.3	.8532	.0916	.0553
F24	0.6	92.6	207.3	15.2	7.2	73.1	.6071	.2895	.1034
F39	280.0	10.1	135.9	2.9	2.1	86.5	.7248	.2286	.0466
Section #10									
F30	55.8	325.8	148.2	0.3	8.2	81.8	.7145	.2018	.0837
F31	344.3	254.2	135.3	4.2	2.3	85.3	.5710	.3352	.0938
F32	352.7	260.7	130.7	11.2	9.8	75.0	.6893	.2505	.0602
F33	340.9	74.4	232.5	8.1	22.8	65.7	.7023	.1580	.1397
F34	334.5	65.5	182.8	10.4	5.4	78.3	.6977	.2372	.0651
F35	146.4	54.8	259.2	6.1	14.2	74.5	.7150	.2112	.0738
F36	4.7	268.8	129.9	15.7	20.2	63.9	.4789	.4019	.1193
F37	337.5	69.5	184.8	14.9	7.3	73.4	.7588	.1755	.0657
F38	332.3	62.4	179.5	3.9	2.0	85.6	.6378	.2876	.0746
Section #11									
F01	31.1	297.2	137.6	8.2	25.5	63.1	.7122	.2061	.0817

Appendix II Grain size analysis

SAMPLE #	meters below	coarse sand percent	medium sand percent	fine sand percent	silt percent	clay percent	mean (phi)	sorting (phi)	skewness (phi)
SECTION # 1									
T99	4.0	12	7	14	36	30	_	_	_
T114	2.0	13	7	16	34	30	_	_	_
T115	1.0	12	10	24	31	24	5.21	4.06	-3.44
SECTION # 2									
T116	5.4	16	8	14	35	28	_	_	_
T117	4.2	16	8	15	33	28	_	_	_
T118	3.2	14	8	16	39	26	_	_	_
T119	2.1	14	7	20	33	26	_	_	_
T120	1.1	13	7	17	34	29	_	_	_
SECTION #3									
T14	6.0	6	6	21	38	29	_	_	_
T16	4.0	8	7	16	37	32	_	_	_
T17	5.0	9	6	16	36	33	_	_	_
T26	11.0	6	5	16	38	34	_	_	_
# 7	9.0	8	5	17	33	37	_	_	_
# 8	5.5	9	5	17	35	35	_	_	_
# 9	2.0	10	6	19	35	31	_	_	_
SECTION # 5									
T37	10.0	11	6	13	40	31	_	_	_
T 38	9.0	9	7	16	37	31	_	_	_
T 40	2.0	13	6	13	35	33	_	_	_
T 42	4.0	15	11	27	32	15	4.27	3.40	-3.61
# 22	1.8	14	8	21	34	22	4.87	3.85	-3.83
#23	2.0	15	7	18	37	23	5.19	4.05	- 4.35
#24	3.0	12	7	15	40	25	5.43	3.76	- 5.80

SAMPLE #	meters below	coarse sand percent	medium sand percent	fine sand percent	silt percent	clay percent	mean (phi)	sorting (phi)	skewness (phi)
SECTION # 5									
# 11	12.0	10	5	15	37	33	–	–	–
# 12	10.0	11	5	13	36	34	–	–	–
# 13	9.0	9	5	15	36	34	–	–	–
#14	8.0	11	5	12	38	34	–	–	–
#15	7.6	14	7	14	34	31	–	–	–
# 16	6.0	12	8	23	39	18	4.78	3.35	-4.02
# 17	5.0	14	8	21	35	22	5.08	3.98	-3.87
# 18	4.0	11	6	17	39	28	–	–	–
# 19	3.0	13	7	17	38	25	5	3.96	- 5.14
# 20	2.0	14	8	25	35	18	5	3.86	- 3.34
SECTION # 8									
T55	7.0	9	6	17	35	32	–	–	–
T56	5.0	5	4	16	38	37	–	–	–
T57	3.0	8	5	16	36	34	–	–	–
T58	1.0	9	6	16	36	34	–	–	–
SECTION # 9									
T51	–	18	7	14	39	22	5	4.08	-5.31
T45	–	19	11	26	29	14	4	3.44	-3.16
T46	–	19	8	15	45	13	4	3.46	-5.60
T47	–	19	8	17	35	20	5	4.12	-3.80
T49	–	16	9	22	35	19	5	3.69	-3.89
T50	–	20	9	20	32	19	5	3.94	-3.64
# 31	–	15	8	19	33	24	5	4.04	-4.09

SAMPLE #	meters below	coarse sand percent	medium sand percent	fine sand percent	silt percent	clay percent	mean (phi)	sorting (phi)	skewness (phi)
SECTION #10									
T62	1.5	11	5	10	40	34	–	–	–
T63	3.0	12	4	9	36	40	–	–	–
T64	4.5	10	3	9	35	43	–	–	–
T65	6.0	11	4	8	35	42	–	–	–
T66	12.0	9	4	10	35	42	–	–	–
T67	11.5	11	5	10	37	38	–	–	–
T68	7.5	10	6	14	38	32	–	–	–
T69	5.0	12	5	12	37	34	–	–	–
T70	3.0	8	6	13	46	27	–	–	–
T71	1.0	12	5	13	40	30	–	–	–
#36	1.0	9	5	11	37	38	–	–	–
#37	3.0	10	5	12	36	36	–	–	–
#38	6.0	13	7	14	34	32	–	–	–
#39	8.0	16	9	15	31	29	–	–	–
#33	12.0	9	5	13	36	36	–	–	–
#34	8.0	11	6	14	37	33	–	–	–
#35	6.0	11	9	16	35	30	–	–	–
SECTION #11									
#43	1.5	13	11	22	35	19	4.79	3.62	-3.97
#44	3.0	12	8	14	41	24	5.57	3.98	-5.55
#45	4.5	12	8	16	39	24	5.52	3.88	-5.38
#46	6.0	13	9	15	38	25	5.52	4.15	-4.94
#47	8.0	10	6	12	35	37	–	–	–
#48	10.0	12	7	13	31	37	–	–	–
#49	12.0	10	6	13	34	37	–	–	–
#50	14.0	13	7	11	32	36	–	–	–
#51	20.0	10	6	12	34	38	–	–	–
#52	30.0	16	10	27	29	18	4.41	3.67	-3.25

Appendix III Pebble lithology (N = sample number, * = % of volcanics)

SAMPLE #	N	Carbonate (%)	Metamorphic & Igneous (%)	Clastic (%)	
Section #1					
P01	100	33	37	30	
P02	100	43	37	20	
P06	100	31	41	28	
P44	100	48	34	18	
Section #2					
P03	100	54	23	23	
P04	53	58	21	21	
P05	100	51	17	32	
Section #3					
P07	100	32	47	21	
P08	100	23	63	14	
P09	100	24	56	20	
P10	100	22	51	26	*(1% volc)
P11	100	22	52	26	
P12	100	30	42	28	
P13	100	30	44	26	
P14	100	28	45	27	
Section #5					
P18	100	56	21	23	
P20	100	48	37	15	
P21	100	43	40	17	
P22	100	35	48	17	
Section #8					
P31	100	56	18	26	
P32	100	31	46	23	
P33	100	40	41	19	
Section #9					
P16	100	55	25	20	
P24	105	55	21	23	
P25	100	52	32	16	*(1% volc)
P26	100	55	24	21	
P27	100	67	12	21	
P28	100	59	21	20	
P43	50	78	6	16	
Section #10					
P34	100	79	9	12	
P35	100	74	10	16	
P36	100	79	6	15	
P37	100	79	8	13	
P38	100	58	26	16	
P39	100	70	17	13	
P40	100	53	29	18	
P41	100	69	13	18	
P42	100	78	10	12	
Section #11					
P47	100	34	52	14	

Appendix IV Summary data for Type 1 Diamicton

KWADACHA

KWADACHA R

KWADACHA RIVER

(ROCKY MOUNTAINS) R

KWADACHA MOUNTAIN

RIVER

FOX R

FOX RIVER

PRAIRIE MOUNTAIN

TRAIL

FORT WARE INDIAN RESERVE
RESERVE INDIENNE
FORT WARE 1

FORT WARE

SUCKER LAKE INDIAN RESERVE 2
SUCKER LAKE RESERVE INDIENNE 2

125°30'W

MOUNT PAUL

PAUL RIVER

FINLAY RIVER

MOUNTAIN

TRENCH

ROCKY

tMCa
tMr/B
tMp
tMpm
tMOd
sgFp
sgFmp
sgFpm
sgFt1
s$Fp
gsAf
gsGpi
fLGp
tsMpm
mGSp
VsGp
B

PAUL RIVER

FINLAY RIVER

ROCKY MOUNTAIN TRENCH

FINLAY RIVER

ROCKY MOUNTAIN TRENCH

DELC CREEK

ROCKY CREEK

RUSSELL CREEK

FINLAY RANGES (MINEKA MOUNTAINS)

GROVE MOUNTAIN

MOUNTAIN

57°15'N

B

tMCa

tMp

tMm

tMd

tMr/B

tMUpm/B

tMOd

tMDm

tsMp

tsMm

tsMpm

sGp

gsGp

gsAf

gsGpi

mGOp

sgFt1

sgFt2

sgFt3

sgFp

sgFpm

sgFm

sgFct1

sgFct2

sgFmt2

s$Fp

s$Fpc

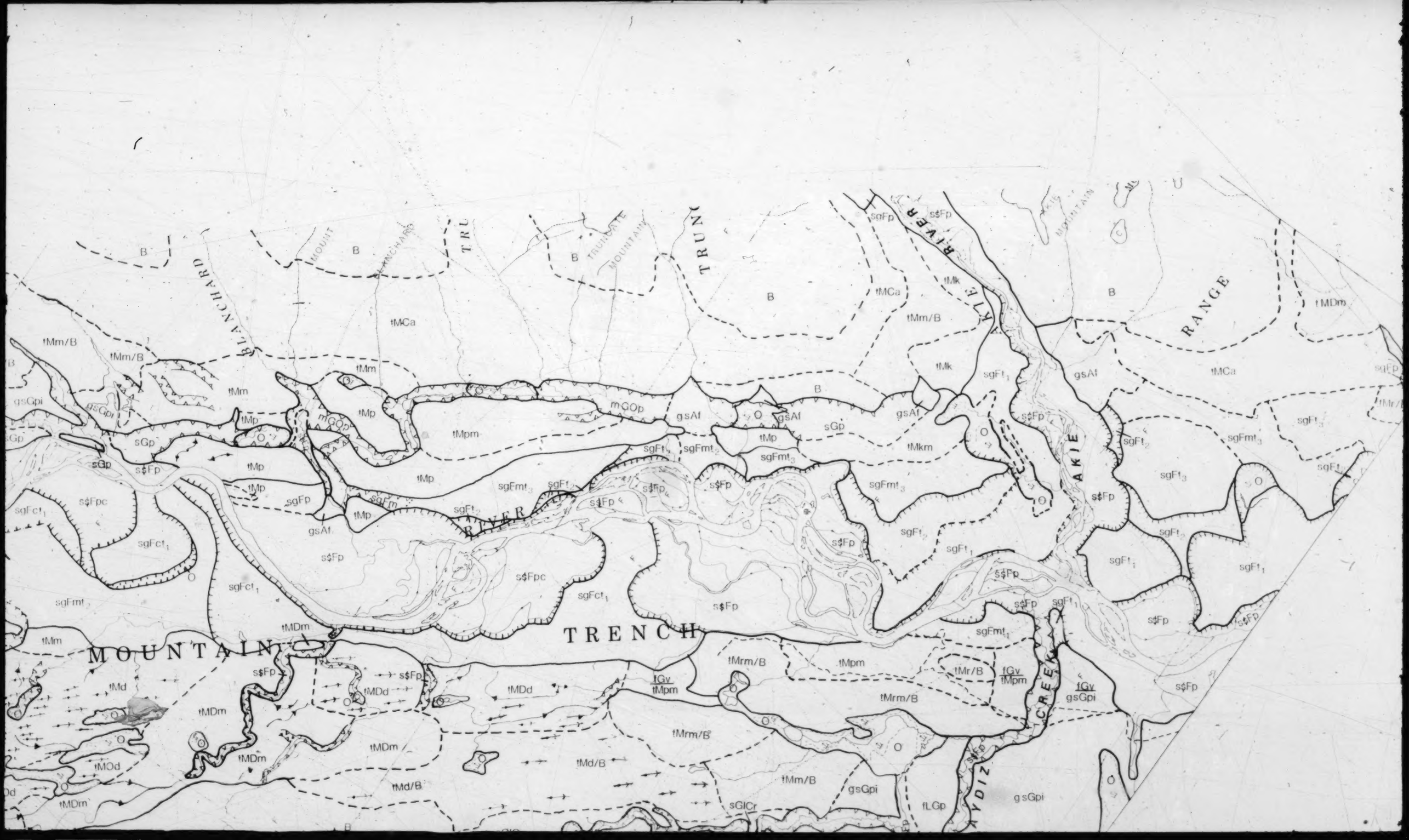
fGv/tsMp

fGv/tsMm

fGv/gsGpi

sGv/tsMp

sGm


MOUNT BLANCHARD
TRUNCATE MOUNTAIN
TRUNCATE MOUNTAIN
RIVER
RIVER
RANGE
TRENCH
MOUNTAIN
CREEK
B
tMm/B
tMm
tMp
tMCa
tMDm
tMk
tMkm
tMpm
tMd
tMd/B
tMOd
tMrm/B
tMr/B
tLGp
sGp
sGpi
gsGpi
gsAf
mGOp
sgFp
s$Fp
s$Fpc
sgFct1
sgFmt2
sgFmt3
sgFt1
sgFt2
sgFt3
s$Fp1
fGv
tMpm
sGlCr
sgFt1
sgFmt1
O

SURFICIAL GEOLOGY AND LANDFORMS OF

FORT WARE AREA,

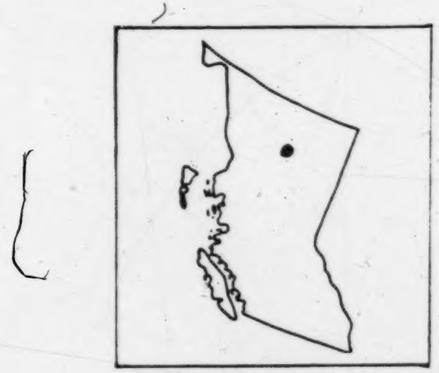
BRITISH COLUMBIA

Scale 1:50,000

Miles 1 0 1 2 3

Metres 1000 0 1000 2000 3000 4000

ELEVATIONS IN METRES ABOVE MEAN SEA LEVEL
CONTOUR INTERVAL.....20 METRES



INDEX MAP

UNIT NOTATION

Composition	Genetic Class	Genetic Modifier	Morphology (relief in m)	
g - gravel	O - Organic	C - Colluviated	a - apron	m - rolling (10-20m)
s - sand	A - Alluvial	D - Dissected/Gullied	c - meander-scrolled	p - plain (<1m)
ɸ - silt	F - Fluvial	U - Grooved	d - drumlinoid (30-50m)	pi - pitted (2-4m)
t - till	G - Glaciofluvial	IC - Ice-Contact	f - fan	r - ridged (eskers-<30m; bedrock->50m)
f - fines; mixture of silt & clay	L - Glaciolacustrine	SI - Stagnant Ice	h - hummocky (5-10m)	t - terraced
m - mixed; fines, sand &/or gravel	M - Morainal		k - kettled (<10m)	v - veneered (<1m)
	B - Bedrock			

EXPLANATION OF UNIT NOTATION

Map units are represented by a combination of letters and sometimes numbers, for example tMo. The lower

LEGEND

UNIT SYMBOL	UNIT NAME	COMPOSITION	TOPOGRAPHIC EXPRESSION	TOPOGRAPHIC SITUATION
	HOLOCENE (RECENT)			
	ORGANIC DEPOSITS			
O	undivided organic deposits	muck, mucky peat, peat, & marl	plain	scattered irregular depressions
	ALLUVIAL DEPOSITS			
A	alluvial fan deposits	generally gravel & sand	alluvial fans; some irregularly shaped	at base of Mount Bennett & other cliffs
	FLUVIAL DEPOSITS			
F	fluvial deposits	generally sand & gravel with minor silt	varies through plain & rolling	bordering Fox River & floodplain of Russel Creek
	fluvial floodplain deposit with silt veneer	interbedded sand & silt with minor gravel & clay	plain, plain to meander-scrolled	occupy floodplains of Finlay & Akie rivers, large creeks & most abandoned channel bottoms
	fluvial terrace deposits	sand & gravel with minor silt	plain, rolling & meander-scrolled terraces	along Finlay & Akie rivers; t_1 = 4-6 m terrace, t_2 = 8-10 m terrace, t_3 = 12 m terrace & t_1-t_2 = undivided t_1 & t_2 terrace
	PLEISTOCENE			
	GLACIOFLUVIAL DEPOSITS			
G	glaciofluvial deposits	gravel & sand with minor silt	plain & pitted	adjacent to till plain deposits
		generally sand & gravel	plain, rolling & veneered	confined to some large meltwater channel bottoms & overbank deposits of these channels
GO	undivided glaciofluvial & organic deposits	gravel, sand, & minor silt, mixed with organics	plain	confined to some large meltwater channel bottoms
GIC	glaciofluvial ice-contact deposits; some with eskers	generally sand with minor gravel & sand	varies through ridged, rolling & rolling	confined to margins of stagnant ice located on western edge of map area between McGraw & Tsaydiz Creeks, & directly north of Stelkuz Lake
	GLACIOLACUSTRINE DEPOSITS			
LG	undivided glaciolacustrine & glaciofluvial deposits	generally fines of silt & fine sand with minor clay	plain	confined to low-lying plains bordering Succour Lake & unnamed lake 2km to the south, & directly north of Tsaydiz Creek
	MORAINAL DEPOSITS			
M	thick (8-20m) morainal deposits	till	varies through plain, drumlinoid rolling & kettled	throughout map area
	thick (8m) to discontinuous (<1m) morainal deposits	sandy till	plain & plain to rolling	throughout map area
MO	undivided	generally till with	drumlinoid	directly south of Mount Bennett & adjacent to till plain

sgFp
sgFmp
tMCa
tMCn
tMpm
gsAf
gsAt
tMr/B
gsGpl
tMp
tsMpm
tMOd
sGlCm
sGlCmr
PRAIRIE MOUNTAIN
MOUNT BENNETT
INDIAN RIVER
RESERVE
SUMMER
LAKE
TRENCH
RANGES
MOUNTAINS
RIVER
CREEK
TELKUZ
57°15'N

ROCKY CREEK

MOUN

FINLAY RANGES

OMINECA MOUNTAINS

RUSSY

STELKUZ LAKE

STELKUZ LAKE

MCGRAW CREEK

125° 30' W

tMr/B
tsMpm
sGp
mGDp
tGv
gsGpi
s$Fp
tsMm
tMm
tMp
tMCa
tMUpm/B
B
BU
tMOd
sgFp
sgFt
sgFm
sgFpm
tMd
tMDm
gsAf
sGlCm
sGlCmr
tMSlm
tMSlhm
sGm
tsMGlCrm
sGlCr
tMr/B
sgFmt
s$Fp
tMm
tMd
tMOd
tMDm
tMr/B
tMCa
B
tMSlm
sGlCmr
tMCa
B
tMSlm
tMCa
sGlCmr
tMr/B
tMSlhm
tMCa
B
B
B

MOUNTAIN

TRENCH

TSKYDIZ CREEK

tMDm

tMm

tMd

tMDd

tMOd

tMDm /

tMd/B

B

s$Fp

sGlCr

tsMSlhr

tsMSlmr

tMSlm

tMr/B

tMCa

tMSlDm

tMSlhm

tMrm/B

tMpm

tMr/B

fGv
tMpm

fGv
gsGpi

tMm/B

gsGpi

fLGp

sGlCrpi

sqFmt

sqFp

O$Al

(S.A)

UNIT NOTATION

Composition	Genetic Class	Genetic Modifier	Morphology (relief in m)	
g - gravel	O - Organic	C - Colluviated	a - apron	m - rolling (10-20m)
s - sand	A - Alluvial	D - Dissected/Gullied	c - meander-scrolled	p - plain (<1m)
ŧ - silt	F - Fluvial	U - Grooved	d - drumlinoid (30-50m)	pi - pitted (2-4m)
t - till	G - Glaciofluvial	IC - Ice-Contact	f - fan	r - ridged (eskers-<30m, bedrock->50m)
f - fines; mixture of silt & clay	L - Glaciolacustrine	SI - Stagnant ice	h - hummocky (5-10m)	t - terraced
m- mixed; fines, sand &/or gravel	M - Morainal		k - kettled (<10m)	v - veneered (<1m)
	B - Bedrock			

EXPLANATION OF UNIT NOTATION

Map units are represented by a combination of letters and sometimes numbers, for example tMp. The lower case letter(s) preceding the upper case letter(s) indicates the composition of the unit. The first upper case letter represents the Genetic Class. If there are two Genetic Classes represented then the deposit cannot be defined as strictly belonging to one Genetic Class, for example tMOd. The Genetic Modifier is represented by upper case letter(s) following the Genetic Class. The lower case letter(s) following the upper case letter(s) represents the morphology. The Composition and Morphology can be represented by more than one letter, in which case the preceding letter is dominant. For example, tsMpm is composed of a sandy till and is morphologically plain to rolling. Numbers are only present where terrace levels have been defined, for example $sgFt_1$ represents a level-one terrace or 4-6 m terrace level morphology.

EXAMPLES

(1) ts M SI hr

Composition: sandy till — Genetic Class: Morainal — Genetic Modifier: Stagnant ice — Morphology: hummocky to ridged

(2) $sgFt_{1-2}$ — sand and gravel fluvial terrace, where levels one and two are represented but cannot be differentiated

(3) tMd / B — drumlinoid morainal till deposit overlying bedrock (Note: notation of underlying bedrock unit indicates that the overlying deposit is thin (<1m) to discontinuous)

(4) fGv / sGpi — veneered glaciofluvial fines overlying pitted glaciofluvial sands (note: all veneered units indicate the underlying unit)

(5) fLGp — plain undivided glaciolacustrine and glaciofluvial fines (note: Genetic Classes cannot be differentiated)

SURFICIAL MAP SYMBOLS

Limit of mapping

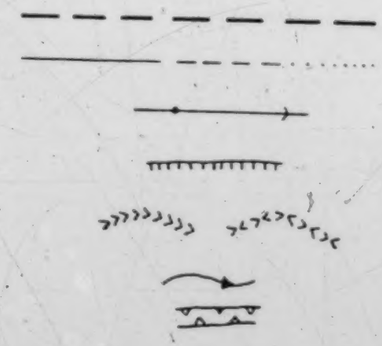
Unit boundary; defined, approximate, assumed

Grooves and drumlins; ice direction known (symbol may represent more than one feature; location and length of feature is approximate)

Terrace escarpment

Esker; direction of stream flow known, unknown

Meltwater channel, abandoned or with underfit stream; minor meltwater channel, direction of flow indicated major meltwater channel



	some with eskers	& sand	& rolling	area between McGraw & Tsaydiz Creeks, & directly north of Stelkuz Lake
	GLACIOLACUSTRINE DEPOSITS			
LG	undivided glaciolacustrine & glaciofluvial deposits	generally fines of silt & fine sand with minor clay	plain	confined to low-lying plains bordering Succour Lake & unnamed lake 2km to the south, & directly north of Tsaydiz Creek
	MORAINAL DEPOSITS			
M	thick (8-20m) morainal deposits	till	varies through plain, drumlinoid rolling & kettled	throughout map area
	thick (8m) to discontinuous (<1m) morainal deposits	sandy till	plain & plain to rolling	throughout map area
MO	undivided morainal & organic deposits	generally till with organic deposits	drumlinoid	directly south of Mount Bennett & adjacent to till plain, directly south of Russel Creek
MC	colluviated morainal deposits	till	apron	along glaciated slopes
MD	dissected/gullied morainal deposits	till	drumlinoid & rolling	eroded till plain with parallel gullies directly south of Russel & McGraw Creeks
MGIC	undivided morainal & glaciofluvial ice-contact deposits; with eskers	sandy till	rolling to ridged	adjacent to valley-marginal channel on western slope directly north of McGraw Creek
MSID	dissected/gullied morainal stagnant ice deposits; some with eskers	till	rolling	confined to west wall of valley-marginal channel on western edge of map area between McGraw & Tsaydiz Creeks
MSI	morainal stagnant ice deposits; some with eskers	till & sandy till	varies through rolling, ridged & hummocky	confined to bottom of valley-marginal channel on western edge of map area between McGraw & Tsaydiz Creeks
M / B	thin (<1m) to discontinuous morainal deposits overlying bedrock	till	ridged; less frequently ridged to rolling	throughout map area where isolated bedrock highs occur
MU / B	grooved thin (<1m) to discontinuous morainal deposits overlying bedrock	till	plain to rolling	restricted to southern lee-side slope of bedrock high directly south of Mount Bennett
	BEDROCK			
B	exposed bedrock	bedrock	ridged	above elevation of maximum ice-limit (1250-1400 m) & also below maximum ice-limit where glacial deposits are minor & discontinuous
BU	exposed grooved bedrock	bedrock	mostly grooved & plain to rolling	below elevation of maximum ice-limit (1250-1400 m) where glacial deposits are minor & discontinuous